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ABSTRACT

The original intent of this project was to improve the quality of the elementary science component of the Utah State University elementary science preparation program. The original impetus for the project resulted from a combination of a desire to continually improve an already sound elementary program, local concern over the quality of science being taught in public schools, and national priorities related to science education. A primary objective was to provide a sound research foundation for the science methods course and to incorporate as many appropriate innovations as possible into the program, assuring that graduates of the program enjoy marketability. Included in this document is the users manual for an elementary science teaching methods program entitled "Self, Others, Discipline, Implementation, and Associate" (SODIA) and a manual designed to provide practical information for curriculum development at the university level. (CW)

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Final Report
Part 1
Project Portrayal

Utah Elementary Science Improvement Project

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PROJECT DESCRIPTION AND EVOLUTION

The original intent of this project was to improve the quality of the elementary science component of the Utah State University elementary science preparation program. The original impetus for the project resulted from a combination of general desire to continually improve an already sound elementary program, local concern over the quality of science being taught in public schools, and national priorities related to science education.

A primary objective was to provide a sound research foundation for the science methods course and to incorporate as many appropriate innovations as possible into the program, assuring that graduates of the program enjoy marketability.

Initial Collaboration

Plans for forming a science education advisory group were initiated in 1983. Informal interactions were conducted by education and science faculty. These meetings led to formation of a formally constituted advisory committee that has survived for five years. The committee consists of appropriate deans, department heads, science and education faculty, students, teachers, and administrators.

The collaborative impacts of this group had major influence on the project. The group's mottos were: "No one of us is as smart as all of us." An atmosphere of give and take and a sincere desire by all involved to improve science education assured good working relationships.

As an outgrowth of an initial needs assessment, the advisory committee identified three main areas of concern:

(1) Elementary teacher graduates did not have a sound content background in science.

(2) Elementary teacher graduates did not have adequate mathematics skills.

(3) The former science methods course was not preparing teachers to teach science as well as we know how to teach science.

After considerable advisory committee discussion and departmental interaction, it was proposed that the elementary teacher preparation program be altered as follows:

Effective 1985-86 school year a 19-credit general education science requirement consisting of 9-10 physical science and 9-10 life science credits was dropped. This requirement was replaced by a uniform general education requirement of Biology 101(5cr), Chemistry 101(5cr), Physics 120(5cr), and Geology 101(5cr). It was assumed that this would provide all elementary teachers with a uniform science background. The newly required courses were all laboratory courses, providing experience with science process skills. The college of science made a commitment to revise these four course offerings, over time, to best meet the needs of elementary teachers. This goal was achieved in principle early in the project, but remains in a state of continuous evolution.

Additional program changes include adding a third 3-credit math course to the two that were previously required. These math courses were revised to better match both college science course needs and elementary classroom needs.

A Research Base

A review of literature was conducted to determine what research said about science methods courses. This research base formed a philosophical foundation for most of the components subsequently found in the methods course and also provided further justification for the content changes made in the total program. This foundation is detailed in "Foundations for an Elementary Science Methods Course" (Daugs, 1986).

In summary, important concepts from the literature included:

1. Students need a sound content background prior to their methods course.

2. Both content and methods courses should have a strong hands-on component.

3. Activities and content should be directly related to what is ultimately taught in the elementary classroom.

4. Appropriate technology should be utilized.

5. Students should have opportunities to demonstrate excellence.

6. All components of scientific literacy must be dealt with.

7. The recent trend to integrate science, technology, and society should be accommodated.

8. There should be more than one way to achieve a given goal.

The SODIA Program as Presently Constituted

The acronym SODIA represents the Utah State University Elementary teacher education program. The name is derived from the first letters of the descriptive words (self, others, discipline, implementation, and associate teachers), which represent the five levels of the program. No research justification for the total program is provided in this report. Figure 1 illustrates the components of the total program.

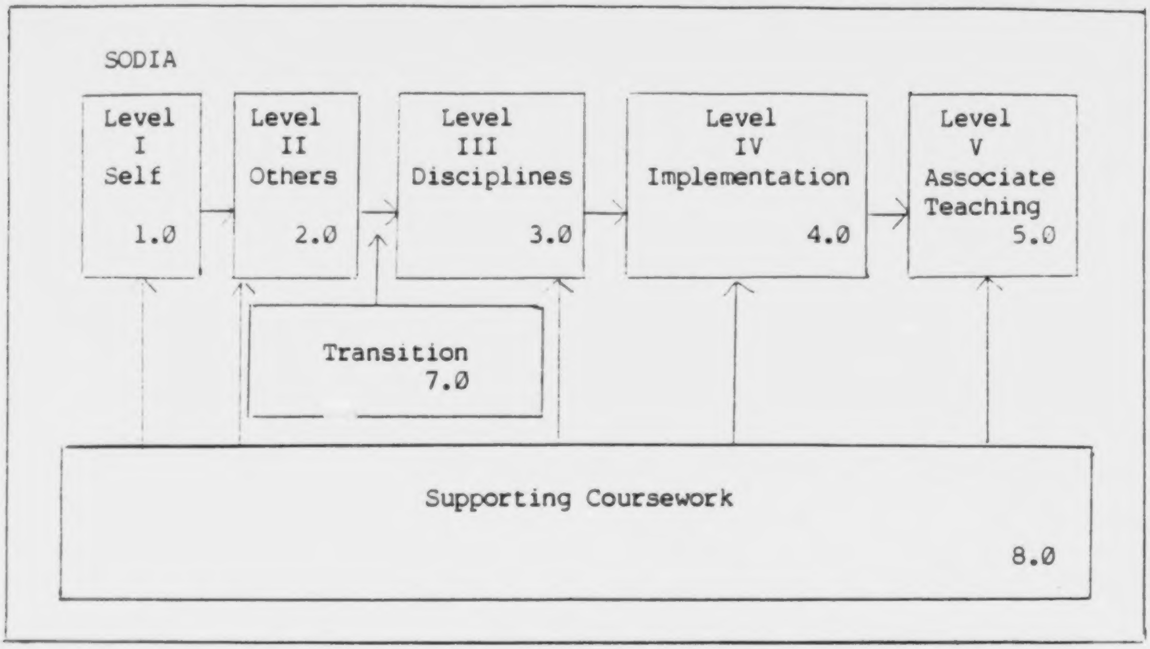
SODIA
Level I Self 1.0
Level II Others 2.0
Level III Disciplines 3.0
Level IV Implementation 4.0
Level V Associate Teaching 5.0
Transition 7.0
Supporting Coursework 8.0

Figure 1 Program Components

Level I, Self, is represented by the letter "S" in the acronym SODIA. At this introductory level, emphasis is on student understanding of the relationships between the individual and ability and desire to teach. Students in Level I receive a minimum of 10 hours of observations in elementary schools at various grade levels. Additional classwork and counseling provide a variety of other experiences to help students decide whether teaching is really the profession they are interested in pursuing.

Level II, Others, is represented by the "O" in the acronym SODIA. Students take a composit of courses in Level II consisting of 15 credits, and are assigned to one of the cooperating public schools. The students spend approximately one-half of each day in classrooms working with teachers and children as tutors and aides. The remainder of the time is spent in seminars and classwork which are offered in cooperating public schools and on the USU campus. The classwork is interdisciplinary in nature. Students receive credit for Educational Psychology, Education of the Exceptional Child, Foundation Studies in Teaching, and Practicum in Elementary Education. (Students in Early Childhood Education also take the Seminar in Early Childhood Education and a Practicum in Early Childhood Education.) Entrance to Level II requires prior admission to Teacher Education and a 2.7 grade point average.

Component 7.0, Transition, includes the new science methods course. The course as inserted in the total program at this point to accommodate the prerequisite science requirements and to facilitate a break between Level II and Level III.

Level III, Disciplines, is represented by the "D" in the acronym SODIA. Students in this bloc receive 15 credits and are assigned to classroom and seminar experiences at the Edith Bowen Laboratory School on the USU campus. The "methods" courses in reading, social studies, language arts, and mathematics are included in this group of courses. Students diagnose, prescribe, teach, evaluate, and reteach in all the subject matter areas. They also develop a variety of methods and approaches using diagnostic and prescriptive techniques.

Level IV, Implementation, is represented by the "I" in SODIA. This is the student teaching phase of the program. Student teaching constitutes a full day of actual teaching experience for a full quarter (13 weeks). Student teachers are assigned to classrooms in public schools. To better qualify and prepare the student teacher to teach grades one through six and provide indepth understanding of the total elementary program, the student teaching quarter is divided into two time blocs. For one bloc, the student teacher may be placed in either a primary or intermediate grade; and in the next bloc the student teacher is placed in a different class on a different grade level. Such assignments may vary and are based on the interests and individual needs of student teachers.

Level V, Associate Teaching, is represented by the "A" in the acronym SODIA. Associate teaching is optional and is an individualized program for senior students who have successfully completed their student teaching and who wish additional experience in the schools. The associate teaching level of the program permits students to make special arrangements to earn from 3 to 12 credits for additional work in an elementary school classroom. At their option, students may:

1. Pursue special interests, such as science or math;
2. Strengthen areas of weakness;
3. Perform almost any desired function in a regular school situation.

POLITICS OF COLLABORATION

People Factors

Having the right people involved in the project was critical. If either the Dean of Education or the Dean of Science had not been committed to the project, it would never have succeeded. Department head commitment was also critical.

The initial task of the project director was to present a convincing case to the above persons. This presentation required not only a documentation of need, but some suggestions for solutions to problems. In the case of this project, everything just seemed to fall into place. We had the right people and a working atmosphere that greatly facilitated the project.

The need to share the goals of the project with the entire department faculty was always high priority. Before the project began, the department was consulted and their approval to proceed was obtained. Progress in the project was reviewed regularly in faculty meetings.

It was within the departmental framework that the only major difficulty occurred. Specifically this related to advisors' hesitation to share the new requirements with students. The increased science content and the change from a three-credit to a five-credit methods course did cause considerable student stress. Advisors were on the "front line" through the transition period and their general tone of response was apologetic and they accommodated many exceptions. This atmosphere may not have changed without a change in personnel.

The cooperation of public school teachers and administrators was very helpful. Their inputs, through the advisory committee, informally contributed to a broad sense of ownership in the program. Though not well documented, there is a general sense of preference for graduates from USU among Utah hiring agencies.

The general collaborative atmosphere of the project has enhanced the image of the department across campus in general and particularly in central administration. The State Office of Education has also recognized the quality of the program and continues to be very supportive of efforts to promote elementary education. Indirectly, the project's reputation has increased the probability of other funding.

MAJOR OUTCOMES

Student Behaviors

More is not always better. More science had the potential of negatively influencing the attitude and performance of the students. Outwardly the physics, math, chemistry, biology and earth science requirements presented an ominous challenge to students. One could have predicted decreased course evaluations and increased negative attitudes. As documented in the Program Assessment Report, these expectations did not materialize. On the contrary, student course evaluations, attitude scores, and content knowledge all increased.

Without reservation it can be stated that the changes made have strengthened the elementary teacher preparation program in all dimensions. The student attitude and competence improvements should have an influence on the quality and quantity of science taught in elementary school classrooms.

People have played a major role in achieving these outcomes. Some persons that taught the foundation science courses were changed over the course of the project. These changes were made to accommodate student feedback on teaching performance. There is more to a course than a course outline.

DEGREE OF INSTITUTIONALIZATION

Elementary Education Program

The science changes have provided evidence that major changes can be made without totally destroying an existing program. The changes are now permanent to the extent that they are fully operational and a part of a total program. However, the elementary teacher program will continue to evolve. All needed resources will be a part of normal departmental procedures. The changes are listed in the University Bulletin as course requirements. Further major changes would require a three-year change cycle.

Extended Institutionalization

The changes modeled by this project achieved University-wide recognition as an example of across-campus cooperation. This acclaim generated "distance learning" interest in the project and has resulted in utilizing the foundation work of the project as a model for "distance learning." As such, the program will be modified for use via satellite and microwave throughout Utah and parts of Colorado.

PRODUCTS AND DISSEMINATION ACTIVITIES

Course Improvement

Prior to this project, student and teacher materials consisted of an assortment of handbooks. These materials have now been organized into a comprehensive users guide (see Appendix I). This document will serve as a textbook for the course beginning fall term 1988.

The users guide is being revised for use in distance learning and has been selected as a model for other such programs. The revised manual will be used for offerings via the Utah State University ComNet facilities. This process links USU with various sites throughout Utah and in Eastern Colorado. The offerings will be adapted to meet both the inservice needs of teachers in rural areas and the preservice needs of elementary programs at various sites.

Papers and Presentations

"Foundations for an Elementary Science Methods Course" (Daugs, 1986) continues to be an in-demand document. This paper provided the research and philosophical foundation for the project.

The USU SODIA-Science Program was selected as one of seven preservice elementary science award recipients for the National Science Teachers Association's Preservice Elementary Science Search for Excellence in Science Education. As such, the project received recognition and exposure at the national NSTA conference in San Francisco. This recognition included an awards ceremony and a "Roundtable" presentation. At the 1986 Association for the Education of Teachers in Science conference, a paper entitled "Innovations in Preservice Elementary Science Methods" provided further exposure. A similar paper was presented at the NSTA conference in Las Vegas in 1987. A summary of the project was included in Focus on Excellence (Penick, 1987).

The project received international recognition in Kiel, Germany in August 1987, where a paper was presented at the 4th International IOSTE Symposium on World Trends in Science and Technology Education. This paper was also published (Daugs, 1987). A paper on the project evaluation procedures was also presented at the ATE conference in San Diego (Daugs and Richards, 1988). A paper on one of the assessment instruments was presented at the 1988 NSTA conference in St. Louis (Daugs, 1988).

The 1989 AETS Yearbook will include a chapter on the project. "SODIA-Science, Innovation in the Preparation of Elementary Science Teachers" has been accepted for publication and includes a comprehensive review of the entire project.

Assessment Instruments

The project has resulted in two valuable assessment instruments. The course pretest, "Scientific Literacy Assessment," was modeled after items from the British Columbia Science Assessment (1982). Validity considerations were covered in the 1982 report. Test items were adopted for local relevance. A reliability of .87 was obtained using the

Livingston criterion-referenced adjustment of Keider Richardson 20.

The other assessment product was the "Elementary Teacher Laboratory Equipment and Materials Assessment Instrument." This instrument was validated and has a Livingston adjusted KR_{20} of .95.

Major Dissemination Product

One of the major goals of the project was to produce a major document that others could use to assist them in going through a similar process. This document, Methods Course Curriculum Improvement: A Users Manual (Daugs and Burbank, 1988) was designed to be a part of an on-going work with other institutions desiring to initiate similar projects (see Appendix 2). The product should form the basis of future dissemination projects. To date, the model has been used for modification of the elementary science program at Brigham Young University and is presently being used to modify the social studies program at Utah State University. Funding will be sought to expand such dissemination applications on a national basis. Funding will be sought for inclusion as a National Diffusion Network Project.

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Appendix 1

SODIA - SCIENCE

A Users Manual
for
Elementary Science Teaching Methods

SODIA - SCIENCE

A Users Manual
for
Elementary Science Teaching Methods

by

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Chapter 1

BACKGROUND INFORMATION

SODIA-Science is the science component of the SODIA Elementary Teachers Preparation Program at Utah State University. The present program has evolved since 1971 when initial efforts were made to develop an elementary teacher preparation model that met the needs of students and had a sound basis in theory. The acronym SODIA is derived from the initial letters of descriptive words (Self, Others, Discipline, Implementation, and Associate Teaching), which describe the emphasis placed at each level of the program.

SODIA-Science was one of seven programs recognized in the 1985 National Science Teachers Association Search for Excellence in Science-Preservice Elementary Teacher Preparation Program. SODIA met all NSTA standards for excellence. In 1985, SODIA-Science received a three-year U.S. Department of Education grant under the Synthesis and Use of Research in Education Project. The purpose of this funding was to identify and document research-based approaches to improvement of teacher education.

Philosophical Foundation

Researchers have long been dismayed by the apparent misconceptions about science held by students (Bady, 1979; Cooley & Klopfer, 1963; MacKay, 1971; Mead & Metraux, 1957; Rubba, Horner & Smith, 1981) as well as about the misconceptions possessed by science teachers (Carey & Strauss, 1968, 1970; Miller, 1963; Schmidt, 1967). It seems logical that improved student conceptions would necessarily follow if programs were designed to improve science teachers' conceptions of science. Such programs (e.g. Billeh & Hassan, 1975; Carey & Strauss, 1968; Welch & Walberg, 1968) assumed that a teacher's classroom behavior is influenced by his/her conceptions of the nature of science and that a significant positive relationship, therefore, exists between teachers' conceptions and changes in the conceptions of their students. However, recent research (Lederman, 1983) has failed to support this inituitive notion. In addition, curricula specifically designed to promote improved student conceptions of the nature of science have provided only limited success.

A National Science Teachers Association position statement (1983) recommended standards for the preparation and certification of elementary science teachers. Much of the rationale for the stated NSTA standards is similar to the rationale for SODIA-Science. The NSTA statement indicated that there is universal agreement that elementary teachers should have reasonable knowledge of science content. The first recommended standard reads as follows:

> All college and universities should require a minimum of 12 semester hours or 18 quarter hours of laboratory or field-oriented science including courses in each of these areas: biological science, physical science, and earth science.

A success-oriented science program must accommodate student ability. Content and methods course students should have concrete experiences as dictated by the fact that most are not at the formal operations stage. However, success in science methods alone may not be sufficient to motivate students to teach science. Bandura (1977) has described a theory of "self-efficacy" which suggests that if a student attributes success to luck rather than ability and effort, success may not lead to greater interest and effort in the future. Students should experience the methods course in such a way that they can attribute their success to personal effort and ability.

In an attempt to relate teaching behavior and classroom climate to students' conception of science, Lederman (1986) identified four variables as "generic" by virtue of their pervasive importance with respect to conceptions of science. They were:

(1) The teacher/classes of the "high" group were typically more pleasant and supportive.
(2) The telling of anecdotes, use of humor, and instructional digression by teachers was more evident in the "high" group.
(3) The "high" group had dynamic teachers.
(4) The "high" group classes employed a variety of instructional media.

Other variables identified in the study may be considered prerequisite variables since they facilitate learning when present. They include:

(1) Frequent questioning.
(2) Questions of a higher cognitive level.
(3) A problem-solving approach.
(4) Sequential probing of student responses.
(5) Relating subject matter to students' lives.
(6) AAAS guidelines (AAAS, 1970) indicate that courses should be related to the science the students will eventually teach.

The above factors speak for a sound foundation in science that is taught in other than the traditional lecture approach. Coupled with this was a general consensus that elementary teachers had a very poor background in science. Locally, in 1980-81, less than half the elementary teachers were teaching any science. Most had little or no science content background and although graduation requirements specified 19 quarter hours of science, the courses were not specified. Nature study was as acceptable as biology, and astronomy was as acceptable as introductory physics.

Piper (1977a) identified four science methods course characteristics considered important by perservice elementary teachers. They were: (1) competencies to be mastered in the course were publicly stated; (2) the instructors modeled the behaviors which preservice elementary teachers were expected to demonstrate; (3) campus activities were planned to assist preservice elementary teachers in having successful field experiences; and (4) instructors provided personalized feedback following field experiences.

Piper (1977b), in another study of science methods courses, also found that stated competencies and field experiences were one way to produce more positive student attitudes towards science.

Katona (1940) identified the strategy of "learning by help". This process focused on principles that must be considered in solving problems. Whimbey (1977) indicated that when the instructor "thinks aloud" to facilitate student understanding of strategies, errors in student thinking will become more evident. The above components contribute to a philosophy best exemplified in the "helping relationship" approach.

The essence of the "helping relationship" approach is that a learning experience should be a joint enterprise of students and teachers attempting to identify and practice ways of relating to each other as real persons in a creative setting (Rogers, 1961, 1963a, 1963b; Faw, 1949, 1957). The basic ingredient in the "helping relationship" approach is people.

Various strategies for problem solving may be utilized in the "helping relationship" situation. Affective considerations include:

(1) The student must desire solution.
(2) The student must feel he/she has the ability to solve the problem.
(3) The student must desire to begin an attack on the problem.

Working in small groups definitely facilitates problem solving (Suydam and Weaver, 1977). These components of research on problem solving can justifiably be applied to the science methods course, with criterion for application: Does the component help create an environment conducive to problem solving? Studies by Brownell (1942), Maier (1970), Simon (1976), and Wheatley (1977) have contributed to structuring problem-solving situations in the science methods course.

The logic of a curriculum framework consisting of goals and objectives may never be perceived by the student (Ausubel, 1963). However, research suggests that students need to know what is expected of them (Baker, 1969; Duchastel & Merrill, 1973; Gleit & Elington, 1978; Kibler etal., 1970). The more freedom students have in the learning process, the more important objectives are in facilitating learning. These factors suggest that there is merit in providing the student with objectives and an explanation of the process involved in achieving the objectives.

Advisory Committee Inputs

Prior to 1981, both students and faculty consistently reported that the term in which methods courses were offered was "heavy". The term consisted of a block of five, three-credit methods courses and a three-credit practicum. The practicum required a half day in the classroom.

Over the years, various concessions were made to accommodate a reasonable balance between methods course requirements and practicum experiences. The most visible accommodation was a reduction in the number of contact hours devoted to the 15 credits of methods courses. This reduction was justified on the basis that students experience a major component of methods experience in the accompanying practicum. In the case of science, this was not a valid assertion. Contact hours were reduced from 30 to 21 hours. However, students reported not being able to teach any science in their practicum due to peculiarities of classrooms to which they were assigned. There was a general feeling among students that they needed more science experience.

To compensate for perceived science contact hour deficiencies, the classroom time for the science course was then reexpanded to more nearly match that of an on-campus, three-credit course. Even with the increased time, students consistently indicated they wanted more time in science methods and evaluated the science methods course highly.

The Science Advisory Committee recommended that the science methods course be made prerequisite to the methods course block and that it be expanded from a three-credit to a five-credit course. It was decided that this would provide an intermediate step in classroom exposure prior to a half-day practicum and would satisfy the students' desire for more science. It would also alleviate the load pressure in the term the other methods courses were taught (Level III).

General national and state concerns (National Science Board, 1983; Milne, 1983) about the science competencies of elementary teachers were discussed by the Advisory Committee at much length. Included in the discussions were the recommendations of the National Science Teachers Association (NSTA, 1983).

Early research (Beryyessa, 1959; Lamors, 1949; Lerrer, 1957; Rutledge, 1957; Wishart, 1961) revealed a positive correlation between science background and various teaching competencies. More recently, research indicates (De Rose, 1979; Fitch 1979) that many elementary teachers feel unqualified to teach science because of their poor science content background.

Although there appears to be almost universal agreement that elementary school teachers should have a good science foundation, few colleges and universities have matched research findings with content offerings. Many science educators (Blosser, 1969; McDermott, 1976; Rowe, 1978; Suchman, 1976; Victor, 1974) also believe that process-oriented elementary teachers should be knowledgeable about the concepts and conceptual schemes that emerge as science inquiry progresses. Only one-third of the institutions surveyed by Stedman (1982) design their science content courses to meet the needs of elementary teachers. AAAS guidelines (AAAS, 1970) indicate there should be a match between science topics that are taught to teachers and the science topics that are taught to children.

The Advisory Group recommended that the general education requirements for elementary teachers be revised to include Biology 101 (5 cr.), Chemistry 101 (5 cr.), Geology 101 (5 cr.), and Physics 120 (5 cr.). In addition, these courses should be modified to include all of the topics covered in the elementary science portion of the Utah Core Curriculum (1983).

They further recommended that the expansion of the science methods course from a three-credit course to a five-credit course include a major science, technology, and society component. This recommendation was based upon a general feeling that Science, Technology, and Society (STS) concerns on a state and national level would influence the elementary curriculum of the future.

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Chapter 2
CURRICULUM FRAMEWORK

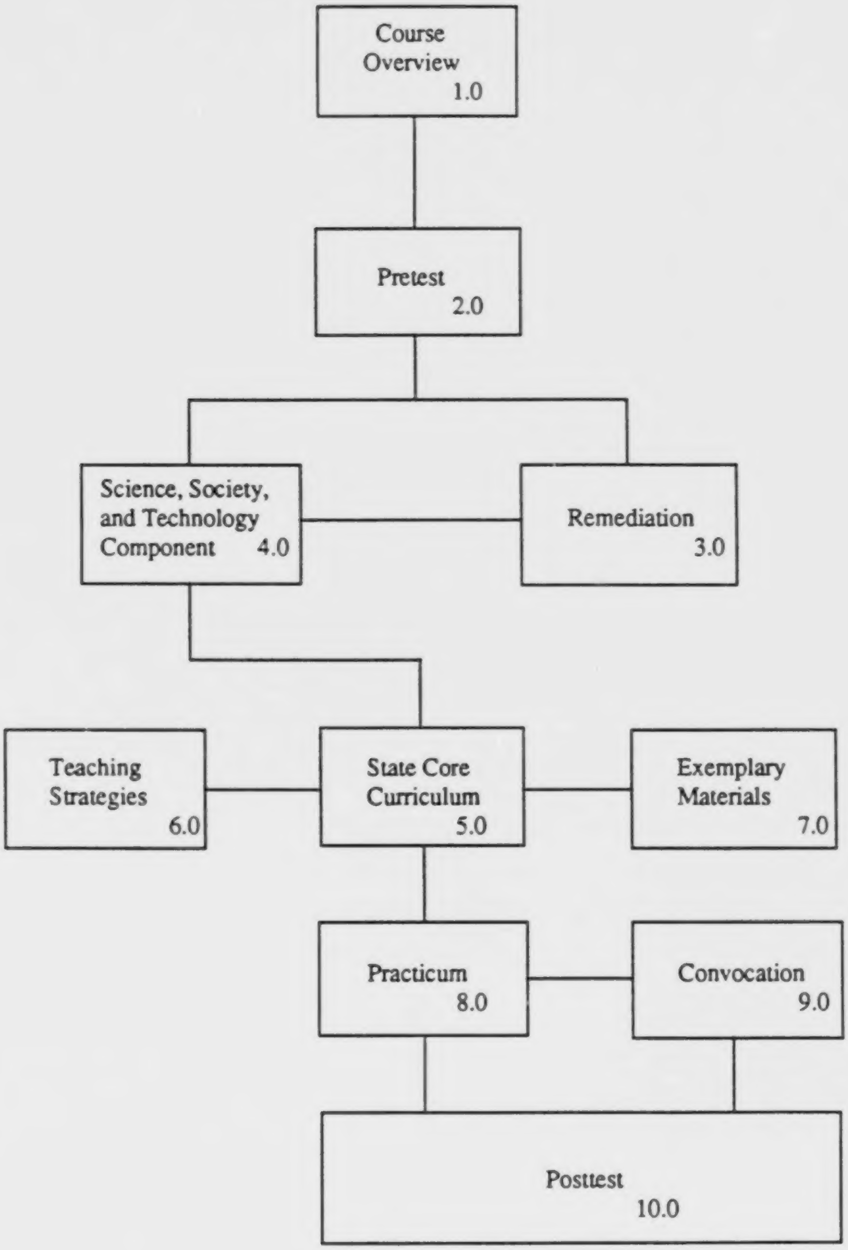
Course Components

A Discrepancy Evaluation Model (DEM) was used in planning the overall design of the science methods course (Yavorsky, 1976). DEM design constitutes a structured description of the program, with information organized so that it can be used as an operational map of the program. The design includes: What is going to happen (activities—process), what should result if the activities are carried out (objectives—outcomes), and what is needed to carry out the activities (resources—input). Evaluation questions and sources of data categories were added to the basic DEM model.

In discrepancy evaluation, performance is compared to be a standard. A program design serves as the formal representation of that standard and is to be stated in a form which makes standards readily subject to evaluation. If organized properly, the program design should facilitate clarification of program goals and facilitate the total planning process.

The methods course is organized around ten basic components as illustrated in figure 1. In the section that follows, each component is outlined by program goal, topic, state objective, and an IPO framework. Each component is discussed at some length.

El. Ed. 401 Science Methods (5 cr.)
Component Flowchart


Course Overview 1.0
Pretest 2.0
Science, Society, and Technology Component 4.0
Remediation 3.0
Teaching Strategies 6.0
State Core Curriculum 5.0
Exemplary Materials 7.0
Practicum 8.0
Convocation 9.0
Posttest 10.0

Program Goal 1.0 To provide an overview and outline of course requirements and procedures.

Topic 1.1 Course Outline

Objective: The student should be familiar with course components.

INPUTS	PROCESS	OUTPUTS
Students	The instructor provides a verbal and written description of the course.	Students will have an understanding of course goals, objectives, and procedures.
Printed course outline		
Classroom to seat 50	Time: 30 minutes	

Topic 1.2 Requirements and Grading

Objectives: The student should be aware of course requirements and options for achieving them.
The student should understand grading procedures.

INPUTS	PROCESS	OUTPUTS
Students	The instructor provides a verbal and written explanation of course requirements and grading procedures.	Students will be aware of course requirements and options for achieving them.
Printed course requirements		
Instructor		Students will understand grading procedures for all components of the course.
	Time: 15 minutes	

Component 1.0 Discussion

Component 1.0 was designed to inform the student of course requirements and what was going to happen in the course. It was inferred from research findings that a high anxiety level generally accompanies poor student performance (Gandry & Spielberger, 1971). The general purpose of topics under Goal 1 is to alleviate anxiety by providing an understanding of what will be required in the course. Karzwell (1968) suggested that building student trust may reduce anxiety and promote better science teaching. Trust is increased when there is a common understanding of events and expectations. Therefore, it is desirable at the outset of the course that students be aware of what will be involved in the course.

McCaulley (1968) studied the distribution of the various learning "types" among students and teachers at various school levels. He found that there were three areas of perference:

(1) Those that prefer to learn by direct immersion in activities, followed by a period of more abstract review.
(2) Those that preferred to be given a picture of the place of the activity in the whole.
(3) Those that preferred to go off in unexpected directions.

One of the major purposes of the course outline is to show that all three of the above options are a part of the course.

The rewards system, as demonstrated most openly by grades, is perhaps the greatest source of anxiety and greatest mediator of attitude. Evans (1976) concluded that grading does not fulfill its purported functions and can produce undesirable motivational effects. The negative effects of external rewards were well described by Deci (1975).

It was considered important that the grading procedure be consistent with the philosophy of meeting individual needs through individualized curriculum. Mutual understanding of course goals, application of evaluation processes and instruments consistent with goals, and student/teacher discussion of grading policy reduce some of the undesirable effects of grading (Robinson, (1979).

Grading is on a point system designed so that all students should be able to attain the highest possible grade. Students should only be tested on things taught in the course. Participation, including attendance and tardiness, are part of the professional behavior and part of the final grade. Some components of the course are repeatable allowing full credit for those experiences. There is no target GPA for the course. However, the following general guidelines apply:

A: Clearly demonstrates excellence in all aspects of performance.

B: Good to excellent performance in nearly all aspects of the course requirements. Clearly above minimum performance.

C: The minimum level of performance acceptable for teaching in the elementary classroom. This does not carry the connotation of average, but rather acceptable performance in every respect.

D: Less than acceptable performance. A student operating at this level should take additional time to improve level of performance or drop.

F: Totally unacceptable performance.

Source of Credit for Grading
(May vary from term to term)

Midterm	0-50 pts.
Final Exam	0-65 pts.
Participation	0-30 pts.
Curriculum Evaluations	0-40 pts.
Lab Safety Assignment	0-10 pts.
Convocation	0-35 pts.
STS Assignment	0-10 pts.
STS Component 4.3	0-50 pts. (Pass-fail)*
	290 pts. possible

*Pass-fail:penalty for unexcused absences or lack of participation. Policy for this component may vary from term to term.

Grading

A = 285-290
A- = 280-284
B+ = 275-279
B = 269-274
B- = 264-268
C+= 259-263
C = 250-258
C- = 244-249
D = 230-243
F = < 230

Program 2.0 To provide a means of determining student level of scientific literacy.

Topic 2.1 Content Assessment

Objective: The student will achieve a score of at least 80% in each of three (life science, earth science, and physical science) content area assessments.

INPUTS	PROCESS	OUTPUTS
Students Pretests	Students will be administered a pretest during a scheduled time.	Identification of those students performing at less than 80% level.
Instructor	Time: 30 minutes	

Topic 2.2 Science Process Skills Assessment

Objective: The student will achieve a score of at least 80% on a comprehensive science process skill assessment.

INPUTS	PROCESS	OUTPUTS
Students Pretests	Students will be administered a pretest during a scheduled time.	Identification of those students performing at less than the 80% level.
	Time: 35 minutes	

Topic 2.3 Science Attitude Assessment

Objective: The student will attain a score of at least 80% on an attitude toward science assessment.

INPUTS	PROCESS	OUTPUTS
Students Pretests	Students will be adminstered a pretest during a scheduled time.	Identification of those students performing at less than the 80% level.
	Time: 10 minutes	

Component 2.0 Discussion

The pretest was modeled after the British Columbia Science Assessment (Taylor, 1982). The pretest consists of five subparts: life, earth, and physical science content, science process skills, and attitude toward science. Validity considerations are covered in the 1982 British Columbia report. Content validity was determined by having approximately 175 elementary teachers, that had been trained as elementary science teacher-leaders, review potential items and eliminate any that they felt were not appropriate for elementary teachers. Test items were also compared with the standards and objectives stated in the Utah Core Curriculum (1987). All test items had comparable core components. Therefore, it was inferred that the pretest covered topics appropriate for Utah elementary teachers.

The 80% competency level on pretests was set arbitrarily. In all literature reviewed by Robinson (1979), the criterion of "minimum competency level" was, in the final analysis, arbitrary. The concept of minimum competency is in tune with Utah State Office of Education policy on Core Curriculum standards for all students. In correlating the preassessment with the State Elementary Science Core (1984), an attempt was made to realistically base all teacher competencies on a foundation of skills and knowledges found in the core. Thus, the minimum expectations for prospective teachers is that they have the performance level expected of their students. This approach rests on the assumption that minimal levels can be specified (Glass, 1976). Much controversy has existed over the issue of ability to measure competency levels. For the purpose of this course, performance levels are indicators based upon stated educational objectives.

The pretest was administered to methods course students during 1985-86. These subjects included both students in a previous science methods course and in the present science methods course. Data from fall and winter terms, 1987, were used to identify faulty test items and to assess item effectiveness. A reliability coefficient was determined for the entire pretest by using scores from subjects that had been administered the pretest over a period of two years (N=249) using the Livingston criterion—referenced adjustment of Kuder-Richardson 20 with KR_{20}=.84 and R_{cr}=.87.

Data was also collected on whether prerequisite science courses had been taken. Consistently, those who had not had the prerequisite science courses did not pass the comparable component of the pretest. At present, nearly all students who have had the prerequisite courses pass the pretest. The usual exceptions are students who had taken a course pass-fail.

Program Goal 3.0 To facilitate, in a variety of ways, remediation of deficiencies identified in pretest procedures.

Topic 3.1 Content Deficiencies

Objective: The student who is below criterion level (80%) in any of the three content areas (life science, earth science, physical science) will:

A. Audit an exisiting course, or utilize a computer-mediated instruction program, or utilize a video-study guide, or arrange an individualized remedial program to improve competencies in the appropriate content area.
B. Retest until the 80% competency level is attained.

INPUTS	PROCESS	OUTPUTS
Students with content pretest scores of less than 80%	The student with deficiencies will elect one or more strategies to improve science content. Students must achieve 80% level of competency on a retest.	Student performance of at least 80% competency level in all science content areas.
Instructor		
Remediation resources	Time: Variable - (Maximum of one year allowed)	

Topic 3.2 Science Process Skill Deficiencies

Objective: The student who is below criterion level (80%) on the science process skills subsection of the pretest will attend instructor-guided remediation sessions.

INPUTS	PROCESS	OUTPUTS
Students with process skill scores of less than 80%	All students will participate in an instructor guided demonstration of science process skills. Students will also be provided self-study process skill guides.	Student performance of at least 80% level of competency on midterm exam process skill test items.
Instructor		
Self-study guide Skill materials Lecture-lab room	Time: Variable	

Topic 3.3 Attitude Toward Science

Objective: The student who is below criterion level (80%) on the attitude subsection of the pretest will discuss, on a one-to-one basis with the instructor, possible implications of attitude toward science on future science teaching.

INPUTS	PROCESS	OUTPUTS
All students Instructor Test scores	All students meet with the instructor to discuss influence of attitude on science teaching. Where appropriate, the instructor and/or student will initiate remediation plans and procedures. Time: Variable	Students with a positive attitude toward science teaching. Some students may plan and carry out attitude improvement strategies.

Component 3.0 Discussion

A foundation of a common core of knowledge and skills was set as a prerequisite to course completion. Students not performing at acceptable levels on the preassessment must select and carry out appropriate remediation.

Work by Thompson (1980) and Kelley (1973) formed a basis for justifying an individualized component to the methods course. Mott (1980) summarized the merits of initial investments of development time to develop individualized programs as related to student performance and attitudes.

Consistent with the concept of individualization of the curriculum, alternative modes of remediation were developed. For each content area, these alternatives include:

(1) Enroll in or audit existing courses;
(2) Utilize a computer-mediated instructional program;
(3) Arrange an individualized remedial program with a faculty member;
(4) Propose some other alternative approach.

The primary responsibility for remediation rests with the student. The course instructor is a facilitator in the spirit of the "helping relationship."

In general, the approach to remediation has been judged acceptable.

Although students with deficiencies have generally elected to use the video-study guide approach to remediation, alternative approaches have also been retained as options. The remediation process does not give the student a profound background in a science content area, but does demonstrate student ability to learn the content required to teach elementary grade level science.

The process skills subtest revealed that many students scoring well on the pretest often could perform the skill, but did not know what the skill was. For example, they could classify objects but did not know that this process was called classifying. Because of this, all students now attend the skills remediation sessions and all students are provided a skills study guide. This approach resulted in nearly 100% success on process skills items on the mid-term exam.

The attitude subtest was designed to be a success-oriented component, the assumption being that if a student was told they had a good or excellent attitude toward science, the person would be more willing to cope with possible content or skills deficiencies. Interviews and counseling sessions have confirmed the above assumption.

Program Goal 4.0 To provide a basic understanding of science-technology-society interactions.

Topic 4.1 Introduction to STS

Objectives:
1. The student will define, compare and contrast science, technology, and society.
2. The student will appreciate how science and technology contribute to new knowledge.

INPUTS	PROCESS	OUTPUTS
Students Classroom Video facilities Video: The Search for Solutions, "Situation"	A video presentation will be used in conjunction with handouts and discussion to introduce the concept of STS. Emphasis will be placed on how science and technology interact to produce new knowledge and new problems. problems.	Students will be able to differentiate between science, technology, and society. Students will appreciate the role science and technology play in generating and solving
Instructor Handouts	Time: 1 1/2 hours	

Topic 4.2 Impacts of Society

Objectives:
1. The student will examine past and present examples of the impact science and technology have had on society, economic growth, a and the political process.

2. The student will infer broad perspectives on the interrelationships among science, technology, and society.

INPUTS	PROCESS	OUTPUTS
Students Classroom Video facilities Video: The Search for Solutions, "Information" Instructor Handouts	A video presentation will be used in conjunction with handouts and discussion to develop the concept of STS interactions. Time: 1 1/2 hours	Students will appreciate the impact of science and technology on society. Students will infer the need for a broad perspective when considering STS issues.

Topic 4.3 Practical Applications

Objectives:
1. The student will examine STS issues that have personal relevance and that can be subjected to scientific inquiry.
2. The student will conduct an STS investigation.

INPUTS	PROCESS	OUTPUTS
Students Science faculty Various equipment	Students will work cooperatively in small groups with a science faculty person. Emphasis will be on solving STS-related problems, using the processes of science. Each student or group of students will carry out an STS investigation. Time: 9 hours	Students will have an increased STS awareness. Students will better relate STS issues to self. Students will conclude that STS issues lend themselves to scientific solution. Students will carry out a personal investigation.

Component 4.0 Discussion

On the basis of course evaluations, it was concluded that students are adequately introduced to the concepts of STS in the first two sessions. Performance was more at the appreciation level than at a profound comprehension level. The videos used and assignments given provide a broad background and an introductory hands-on experience.

The real strength of the STS component lies in utilizing science agriculture and engineering faculty as teachers for component 4.3. The class is divided into small groups and assigned to an outstanding scientist for about nine hours of interaction. During this time, each professor conducts an STS-related science experience for the group. This experience gives the student exposure to the best of science, the best of science faculty, and an opportunity to experience first-hand a STS-related investigation.

The College of Science fully supports this concept, and cooperating faculty go far beyond the call of duty to serve the education students. This collaborative effort is one of the true highlights of the program.

Program Goal 5.0 To provide background on the origin and requirements of the Utah Elementary Science Core.

Topic 5.1 Elementary Science Core Overview

Objective: The student will utilize the Utah Core Curriculum and the Elementary Science Resource Guide as examples of computer-managed curriculum.

INPUTS	PROCESS	OUTPUTS
Students Instructor Lab school principal State Science Core Elementary Science Resource Guide Computer facilities	The Utah Elementary Science Core will be introduced in a lecture-discussion session This will then be tied to a computer-mediated curriculum resource which includes the Elementary Science Resource Guide. Time: 1 1/2 hours	Students will understand the relationships between the State Elementary Science Core and the Elementary Science Resource Guide. Students will utilize a computer-managed curriculum process to obtain science teaching resources.

Component 5.0 Discussion

Classroom experiences in the science methods course are organized to familiarize the student with a variety of curriculum components, including the Utah Core Curriculum, hierarchial arrangement of standards and objectives, computer-mediated curriculum management, science lesson plans, textbook correlation, integration of the total elementary curriculum extensions, and gifted and talented applications. The Utah State Core consists of a set of standards and objectives, arranged by grade level. This framework has been keyed to a numbering system and expanded into a computer-mediated curriculum retrieval system called the Utah Elementary Science Resources Guide.

There is no research justification for inclusion of the Guide in the new methods course. The decision was pragmatic in that it was thought that the guide would be a good introduction to computer-managed curriculum and would serve as an introduction to the Utah Core Curriculum.

The Utah Elementary Science Resource Guide consists of curriculum materials organized in a prescribed format and available on Apple II compatible diskettes. The resources are all keyed to Utah Elementary Science Core standards and objectives. For each standard and objective, the guide supplies the following:

1. a statement of the standard and objective;
2. appropriate vocabulary keyed to World Book Encyclopedia to give content background for the teacher and/or student;
3. one or more basic lesson plans that can be used by the teacher to achieve the stated objective;
4. a listing of a variety of textbook sources that treat the same topic;
5. suggestions for correlation with the rest of the curriculum, e.g. ties to math, reading, and language arts;
6. suggestions for extensions and gifted and talented activites.

The component is team taught by the Edith Bowen Lab School principal and the course instructor. The inclusion of the principal was made to provide an introduction to a computer-mediated curriculum management system utilized in the lab school in which methods course students do their practicum. The inclusion of the total management system expanded the original intent of using the computer as a resource for science curriculum materials to a more relevant total picture.

The use of computer-mediated videodisc was also added to the presentation.

Program Goal 6.0 To apply teaching principles, skills, and methods to teaching elementary science.

Topic 6.1 Scientific Literacy

Objectives: The student will define scientific literacy, apply the concept to classroom situations, and identify or devise means of assessing student levels of scientific literacy.

INPUTS	PROCESS	OUTPUTS
Students	The concept of scientific literacy will be introduced in a lecture-discussion session.	Students will operationally define scientific literacy.
Instructor		
Various curriculum materials	Various curriculum materials and handouts will be used to assist in developing assessment items.	Students will recognize examples of lessons that develop comprehension, application, and attitude components of scientific literacy.
	Students will identify and devise assessment items that measure the components of scientific literacy.	
	Time: 1 1/2 hours	

Topic 6.2 Historical Perspective

Objective: The student will demonstrate a basic understanding of the develop ment and characteristics of elementary science curricula over time.

INPUTS	PROCESS	OUTPUTS
Students Instructor Curriculum samples of historical significance	The instructor will provide historical background on the evolution of elementary science curricula. Sample materials illustrating various approaches to teaching elementary science will be made available. Time: 1 1/2 hours	The student will identify and describe examples of five generations of elementary science curricula. The student will identify strengths and weaknesses of various elementary science curricula.

Topic 6.3 Multidisciplinary Approach

Objective: The student will investigate potential for integrating elementary science with the total elementary curriculum.

INPUTS	PROCESS	OUTPUTS
Students Instructor Elementary Science Resource Guide ESSP PLT, PW	The instructor will model a number of examples of tying science to other parts of the curriculum. Resources will be shared that exemplify integration of science with other subject areas. Time: 1 1/2 hours	Students wil relate science objectives to other subject areas. Students will apply principles learned in this component to practicum and/or convocation experiences.

Topic 6.4 Laboratory Techniques and Equipment

Objective: The student will demonstrate familiarity with laboratory equipment and supplies commonly used in elementary science programs. The student should be aware of hazards and safety precautions associated with elementary science laboratory work.

INPUTS	PROCESS	OUTPUTS
Students Instructor Lab safety manual School Science Safety Station studies equipment	Students will follow self-instructional procedures to familiarize themselves with common elementary science equipment, supplies, and safety procedures.	Students will identify, describe, and appropriately use common elementary science equipment and supplies. Students should be aware of hazards and safety precautions associated with elementary science laboratory work.

Component 6.0 Discussion

The material covered in 6.0 is what is found in most traditional science methods courses. Scientific literacy is covered in detail, along with a historical perspective.

Program Goal 6.2 reflects a philosophy that promotes teaching elementary science as an integrated part of the total elementary curriculum. Historically, the elementary science curricula of the 1960's were good science and were taught as science for science's sake. A tendency, first established by the Lippincott Elementary School Science Program and the Modular Activities in Programmed Science, to teach science in a multidisciplinary mode, is now reflected in many programs. Based on evidence from students that indicate science experiences enhance cognitive skill development and have positive effects on language arts skill development, Mishler (1982) recommended that science and language arts be integrated. Wellman (1978) reviewed educational research and demonstrated a clear and positive relationship between science and language arts.

E. H. Moose (1903) long ago suggested that science and math be integrated "so that always students' mathematics should be directly connected with matters of thoroughly concrete character..."

It has been demonstrated by Almy (1970), Renner (1971), and Stafford (1969) that a child's level of thought influences achievement in mathematics. It can be inferred from these studies that there is at least an indirect relationship between science and mathematics.

Science can also promote creativity. Torrence (1962) included hypothesis forming as a part of creative thinking. Children involved in science activities also develop a reservoir of experiences that can be tapped through creative writing.

Much research has been reported on transfer of training related to the topic of integration of science with other disciplines (Judd, 1939; Bayles, 1960; Gagni, 1962; Cranbach, 1963; and Orata, 1941). Kern (1979) indicates there are three ways to integrate curriculum. The approach followed in the science methods course is what Kern terms a "fused curriculum in which the areas are taught as one."

Research indicates that experience-based elementary science programs foster development of language and reading skills (Barufaldi and Swift, 1977). Wellman (1978) conducted research that indicates elementary science instruction can increase achievement scores in reading and language arts, and can also offer alternative teaching strategies to motivate children with difficulties in these areas. In another study, Wellman also found evidence that science instruction improves reading skills in grades 4, 5, and 6:

> Some of the benefits that intermediate-grade children have been found to derive from science instruction are: vocabulary enrichment, increased verbal fluency, enhanced ability to think logically, and improved concept formation and communication skills.

In the hazards and safety precautions section of component 6.4, students use a study guide and a lab safety manual to self-instruct with respect of the objective. Familiarity with laboratory equipment and materials commonly used in elementary science should be achieved in the four foundation science courses. A brief review should suffice as part of the methods course.

Program goal 7.0 To familiarize students with exemplary elementary science curricula.

Topic 7.1 Industry and Non-profit Organization Curricula

Objective: The student will describe the major features of a variety of third generation curricula.

INPUTS	PROCESS	OUTPUTS
Students Instructor Evaluation forms Curriculum Materials Project Wild Project Learning Tree Water Education K-6 Energy and Man's Environment	Materials will be shared in a variety of formats, ranging from brief (1 hr.) classroom presentations to full day (6 hr.) workshops. Resource people will assist the instructor in the full-day workshops.	Students will identify desirable and undesirable features of industry or non-profit organization produced materials.

Resource persons		
Workshop materials	Time: Variable	

Topic 7.2 Publisher-Produced Curricula

Objective: The student will be able to describe the major features of two publisher produced K-6 elementary science curricula.

INPUTS	PROCESS	OUTPUTS
Students Instructor Classroom sets of two textbook series	Students will evaluate two textbook approaches to teaching elementary science. One examination will be a self-study approach and the other will be an instructor lecture demonstration.	Students will describe the desirable and undesirable aspects of at least two publisher-produced elementary science textbooks.
Study guide	Time: 4 hours	

Topic 7.3 Supplementary Materials and Journals

Objective: The student will be familiar with resources found in Science and Children and Science Scope.

INPUTS	PROCESS	OUTPUTS
Students Instructor	The instructor will introduce and share sample activities from NSTA publications.	Students will identify Science and Children and Science Scope as NSTA publications.
Science and Children, Science Scope	Students will complete an assignment related to one of the shared publications.	Students will be aware of materials available from NSTA.
Handout		

Component 7.0 Discussion

Traditionally, much science methods course time has been devoted to familiarizing students with curriculum materials. However, review of the literature on science methods course research reveals little or no evidence on how to best incorporate curriculum material into a methods course. Gremli (1985) probably identifies the most realistic variable that precludes in-depth exposure to curriculum materials, that being the reality of the classroom. Given such findings, and the intuitive feeling that all existing curricula cannot be covered in any in-depth way, the approach in the science methods course will be to broadly familiarize students with a variety of curriculum material, but not immerse them in any one program or set of materials.

Program Goal 8.0 To provide the opportunity for students to teach a series of science lessons in an elementary or middle education classroom.

Topic 8.1 Practicum

Objective: The student will work with a cooperating classroom teacher to plan, teach, and evaluate an elementary science teaching experience.

INPUTS	PROCESS	OUTPUTS
Students Cooperating teachers Lab School facilities	This component is designed to give the student an opportunity to teach science lessons in an elementary classroom. The classroom teaching will be done in an Edith Bowen Lab School classroom as part of the Level III practicum.	Students should demonstrate professionalism in dealing with cooperaing teachers, principals, and students. Students should demonstrate ability to plan effectively. Students should teach three or more science lessons.

Component 8.0 Discussion

The merits of actual classroom practicum experiences are widely documented (Repicky, 1977; Weaver, 1979; Sunal, 1978; Harty, 1984).

The practicum for the science methods course occurs during the methods block practicum in Edith Bowen Laboratory School. A pass/fail grade is assigned by cooperating teachers for half-day practicum experiences that extend over an entire term. Students must teach some science during that time period.

Program Goal 9.0 To provide a culminating experience where students can demonstrate teaching competencies.

Topic 9.1 Convocation

Objective: The student will plan and conduct a special science learning experience for a small group presentation.

INPUTS	PROCESS	OUTPUTS
Students Instructor Cooperating Elementary Schools Various resources	This component provides the student with an opportunity to demonstrate mastery of science content and teaching. Each term, a special topic or topics are selected for development. Students review aspects of scientific literacy, teaching skills, and assessment. Small groups or individuals plan special learning experiences that are carried out in a variety of settings. Format and topic vary from term to term.	Students should demonstrate ability to work with a variety of people. Students should be able to plan effectively. Students should make appropriate space, equipment and people arrangements. Students should conduct the convocation in a professional manner.

Time: 8 hours

Component 9.0 Discussion

The concept of a convocation as a culminating activity was a product of experience with science fairs, invention conventions, and exposure to the "convocations" approach used in the Albuquerque public schools.

Format for the convocation varies from term to term. Basic ingredients included: a science topic, lots of planning, and a full day of teaching science in an elementary school or small group presentations. The component was a practical way for methods students to demonstrate mastery of content, materials, and teaching skills.

Program Goal 10.0 To provide a means of measuring growth and exit level of performance.

Topic 10.1 Posttest

Objective: The student will demonstrate mastery of course objectives in accordance with prescribed (80%) criteria levels.

INPUTS	PROCESS	OUTPUTS
Students	Testing will cover all major aspects of the course.	Students will demonstrate test performance at the 80% or better level.
Midterm exam	Grading is set up so that students performing at less than the 80% level of competency on exams will obtain less than a passing grade for the course.	

Component 10.0 Discussion

Student performance on midterm and final exams has been outstanding. Grade distributions are consistently higher than college averages. Student course evaluation data indicated a general approval of tests and a feeling that tests matched objectives and course expectations.

No effort has been made to standardize the midterm and final exams. Validation and reliability data are not available on these tests.

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Chapter 3

SCIENCE AND SCIENTIFIC LITERACY

What is Science?*

Science is . . .

- "We're learning all about them. There are all kinds like stop, go, and street signs." Charlotte - Kindergarten

- "I think I have it in my nose. It's when you itch and sneeze and get a runny nose and you have to take pills for science decongestion like on TV." Phillip - Grade 1

- "After lunch sometimes when there is nothing else to do." Shawn - Grade 1

- "I don't think I can have science yet. I'm not a good reader." Jeremy - Grade 1

- "It is the opposite of social studies." Luanne - Grade 3

- "The same old stuff. I've seen the same filmstrip on erosion three years in a row."

- "It depends on what grade you're in and who your teacher is. If a teacher doesn't like science, then you don't get it very much. Once when the principal was coming, Mrs.—did this neat experiment with a tin can and a candle and a balloon, but that was the only time." Greg - Grade 5

- "Supposed to be about learning how we learn about the world and how to use the scientific method in thinking. I know because my Dad is a scientist and he keeps asking me when we're going to learn that in science. I just tell him that we haven't gotten to it yet." Doreen - Grade 6

We study science . . .

- "Because the principal said we have to." Elena - Grade 1

- "Probably because we have science books." Joey K. - Grade 1

- "Because we might turn into scientists when we grow up." Kristin - Grade 1.

- "Because it is important. It is a law from President Reagan and it says so in the Bible on the first page." Jolene - Grade 2

*Notes provided by Cathy Vallentino

- "We don't. We don't have enough books for everyone so my teacher said, 'that's that!'" Darryl - Grade 2.

- Because my teacher could get sued if we don't. That's what she said. Any subject we don't know - Wham! She gets sued. And she's already poor." Corky - Grade 3.

- Not everyone does. I don't think Mrs.—from last year ever did. That's probably why they put her back to the second grade this year." Andy - Grade 6.

Definition of Science (Component 3.0)

Aristole defined science as "The search for truth." This definition included the study of everything from religion to physics. We can still accept the definition, but we must state some criteria for acceptance. First, the "search" part of the definition must include the accepted science process skills, such as: observing, describing, inferring, hypothesis testing, etc. These skills are discussed at some length in the chapter on process skills.

The search part of the definition is the doing or process of science. Truth is the product of the doing. However, truth needs further definition. Truth is evidence of things as they are now, as they were in the past, or as they may be in the future. The evidence is gathered through the use of science process skills. Sensory input, observation, is basic to obtaining any truth.

The truths of science are "t" not "T" truths. They are the kind of truth that nearly everyone can agree upon, the kinds you get with replications of an experiment, but they are tentative. They may be in error.

Scientific Literacy (Component 6.1)

A person's level of scientific literacy is experience dependent. Everyone will have some level of scientific literacy with respect to every concept of science. If the person has had no experience with a concept, then the literacy level will be zero.

We use written or spoken symbols to represent concepts. For every concept of science, a person will have a profile of scientific literacy that includes **concept level, comprehension level, application level, and attitude level.** A person's **concept level** of scientific literacy refers to what is called to mind by a language symbol. For example, the symbol H_2O calls something to mind. This mental image, process, or pattern can not be determined by looking at a person. However, by conversing with a person, it is easy to obtain the person's **comprehension level** of scientific literacy with respect to H_2O. **Comprehension level** refers to how a person puts a concept into language.

Application level of scientific literacy refers to how we use the science process skills and/or the materials and equipment of science. A person that understands the electrical nature of H_2O can apply this to float a paper clip on water.

The fourth component of scientific literacy is **attitude level**. Attitude level can be variously assessed. Indicators range from enjoyment to time on task. Activities that are enjoyable and promote success tend to improve a good attitude.

The pretest for this course measured the three measurable components of scientific literacy. The comprehension component had life science, earth/space science, and a physical science component. The application component included the science process skills, and a few items measured your attitude toward science. Your final score in each major area resulted in a profile of scientific literacy.

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Chapter 4
SCIENCE PROCESS SKILLS (Component 3.0)

The science process skills are the "doing" or process part of science. These skills have often been used by students in science lab experiences, but may never had been defined. The primary purpose of this chapter is to define and give a basic "hands-on" experience with some of the skills. Many of these activities have been adapted from Stepping Into Successful Science Teaching (1986).

Definition of Terms

Observing: Using the five senses to find out about objects and events.

Classifying: Grouping things according to similarities or differences.

Communicating: Using the written and spoken word, graphs, drawings, diagrams, maps, or tables to transmit information and ideas to others.

Measuring: Developing and using appropriate units of measurement for length, area, volume, time, weight, and temperature.

Inferring: Using both observation and past experiences to explain an event.

Defining Operationally: Creating a definition by describing what is done and observed.

Investigating: Formulating and solving a problem, which may include:

- Formulating Hypotheses - making educated guesses based on observations and inferences about the same class of objects or events.

- Controlling Variables - identifying the variables of a system and selecting the manipulated, constant, and responding variables in order to manage the conditions of an investigation.

- Interpreting Data - Finding patterns among sets of data that lead to the construction of inferences, predictions, or hypotheses.

- Predicting - making forecasts of future events or conditions based upon observations or inferences.

Creating: Using intelligence and "stuff" to generate new things.

The activities that follow are set up so that they can be done in groups, pairs, or individually and with or without the instructor. Potential answers follow each activity.

Observing: Activity 4-1

Through the five senses of sight, smell, touch, taste, and hearing we observe objects and natural phenomena in our environment. The data accumulated through observation leads to questioning, searching, seeking, examining, analyzing, investigating, and forming interpretations about our environment. Therefore, observing is the fundamental process that underlies the development of the other process skills such as classifying, measuring, communicating, inferring, and predicting. Observations can be qualitative in which the senses are used to gather data, or quantitative in which objects or phenomena are compared to some standard unit of measurement (linear, volume, mass/weight, force, temperature). Qualitative observations should involve all the senses and not rely solely on sight; however, in some instances you may want to omit tasting. Reference points for qualitative properties such as small, soft, smooth, etc. make observations more precise (small as a penny). Observations in which you act on the object (roll, burn, dissolve) expand the information gathered through the senses. Finally, good observations should include properties that are unique to the particular object or phenomena being observed.

The purpose of this activity is to give you practice in using your senses to gather information and to become aware of the different kinds of observations that can be made about objects and phenomena. The materials needed for this activity are: a birthday candle, clay for a base, matches, and a tape measure. In the spaces provided, list your observations before, during, and after the birthday candle is burned. Identify the sense you used to make your qualitative observations and the instrument you used to make your quantitative observations.

Materials per pair:

Birthday candle
A piece of clay for a base
Matches
Metric tape measure (Refer to participant's instructional materals, Section 4-4.)

Description of Activity:

This activity promotes the involvement of the participants in making quality observations. Good observations include more than the sense of sight; our other senses can also be used to make observations. Observations are made more precise by using quantitative terms and/or giving a reference point for qualitative properties.
Caution: Keep painted finger nails away from the flame.
Caution: Do not make any quantitative measurements while the flame is burning.
Do it! Get the materials and record your observations.

Observations Before Burning

Qualitative	Sense Used

Quantitative	Sense Used

Observations While Burning

Qualitative Only	Sense Used

Observations After Burning

Qualitative	Sense Used

Quantitative	Sense Used

Compare your answers with those of other groups.
Refer to the possible answers that follow.

Potential Answers
Activity 4-1

Qualitative Observations	Sense
Before:	
1. Color: White	sight
2. Slight odor	smell
3. Undetectable taste	taste
4. Cylindrical shape	sight
5. One end flat, other end cone shaped	sight
6. From cone extends a tuft of white, fuzzy, fibrous, soft material composed of strands	sight
7. Each strand is cylindrical and irregularly coiled	sight
8. Wick is crooked	sight

Quantitative Observations	Instrument
1. 5 cm. long	metric tape measure
2. 5 mm. diam.	metric tape measure
3. Each strand is .5 mm in diam.	metric tape measure
4. Coil of strands 1 mm in diam.	metric tape measure
5. Coil extends 5 mm above tip of cone	metric tape measure

Qualitative Observations	Sense
During:	
1. Fibrous strands turn black	sight
2. Flame is elliptical in shape	sight
3. Flame flickers in slight wind	sight
4. Upper part of flame is dull yellow with a blue margin	sight
5. A puddle of liquid forms in place of cone	sight
6. Liquid material drips down side of candle; some solidifies on a cooler part of the candle, some drips to the table top	sight
7. Flame is hot to the touch.	touch
8. Sooty odor from flame	smell
9. Candle is cold at bottom	touch
10. Candle is becoming shorter	sight

11. Feel heat and moisture coming from flame	touch
12. Candle is softer at top than bottom	touch
13. Can see flame's reflection in melted wax on top	sight
14. The melted wax burns your fingers to the touch	touch
15. If the candle is turned upside down, the flame goes out	sight
16. If the candle is turned upside down, wax drips faster	sight

Qualitative Observations	Sense
After:	
1. Color: white	sight
2. Solid, irregular in shape	sight
3. Small portion of fibrous stands protruded from mass	sight
4. Exposed fibrous strands are black	sight
5. Wick is white (just under the burned part)	sight
6. Candle has soot running down it	sight
7. Black ring around area of candle's top	sight
8. The wax once melted and dried is cold	touch
9. The candle is sticky to the touch	touch
10.The melted, cold wax is very brittle when pressure is applied	touch

Quantitative Observations	Instrument
1. Height of mass at highest point 3 mm	metric tape measure
2. Distance across mass at widest point 1 1/2 cm	metric tape measure

Compare your answers with the other members of your group.

REFERENCES

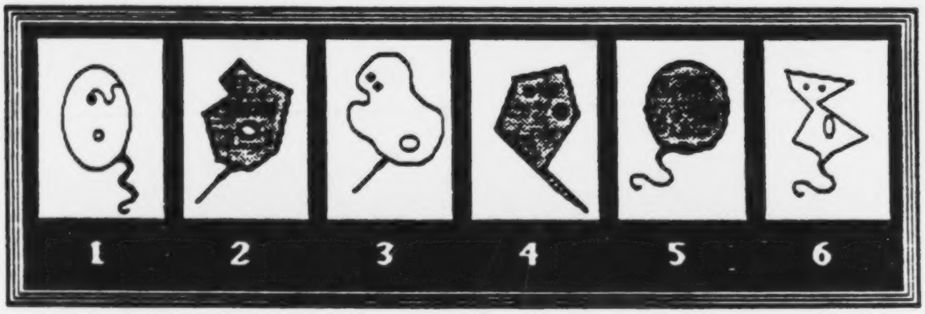
Funk, H. James; Field, Ronald L.; Okey, James R.; Jaus, Harold H. & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Lewis, Melanie C. & Ostlund, Karen L. Stepping Into Successful Science Teaching, EARDC No. El-86, Aug. 1986. Edwards Aquifer Research and Data Center, San Marcos, Texas.

Classifying: Activity 4-2

Classifying is the system by which we impose order on the multitude of events, living things, and nonliving things in our environment. By observing similarities, differences, and interrelationships, we can group items into various schemes. In the following activities, you will classify buttons on the basis of their observable features.

In the first activity, a binary classification system will be constructed in which a set of buttons will be divided into two subsets according to whether or not each button has a particular feature. For example, observe the similarities and differences in the "wild things" pictured below. They can be grouped into two subsets by the observable feature of curley tail wild things 1, 5, and 6 have a curly tail and wild things 2, 3, and 4 do not have this feature.



FEATURE	HAVE	DO NOT HAVE
1. Curly tail	1, 5, 6	2, 3, 4
2.		
3.		

Materials per pair:

6 buttons (2 colors, 2 sizes, 2 with different numbers of holes)

Description of Activity:

This activity involves the participants in classifying buttons based on common properties which they identify. Discuss the relationship between classifying and observing. Go over the directions and examples for each part of the activity. Work in pairs to read the explanation and directions, get the materials, and complete that part of the classification activity.

You now need a set of 6 buttons. Look for similarities and differences in the set of buttons. On the lines below, list at least three features by which the buttons can be grouped into two subsets. In the "Have" column, write the number(s) of the buttons that have the feature that you have identified. In the "Do Not Have" column, write the number(s) of the buttons that lack this feature. Make sure that for each feature the subsets include all the buttons in the original set of 6 and that each button can be placed in one and only one of the subsets.

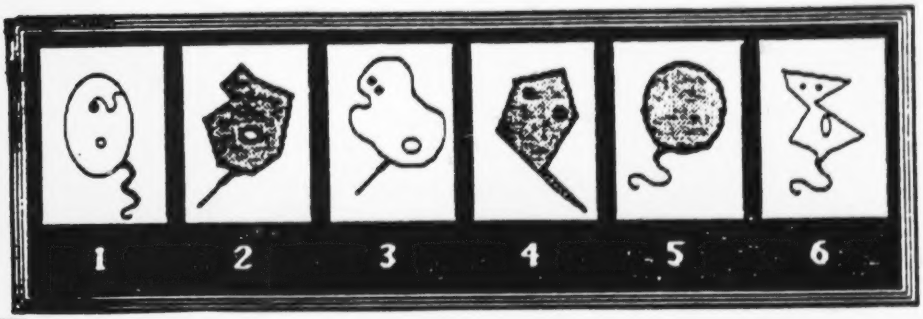
	FEATURE	HAVE	DO NOT HAVE
1.			
2.			
3.			

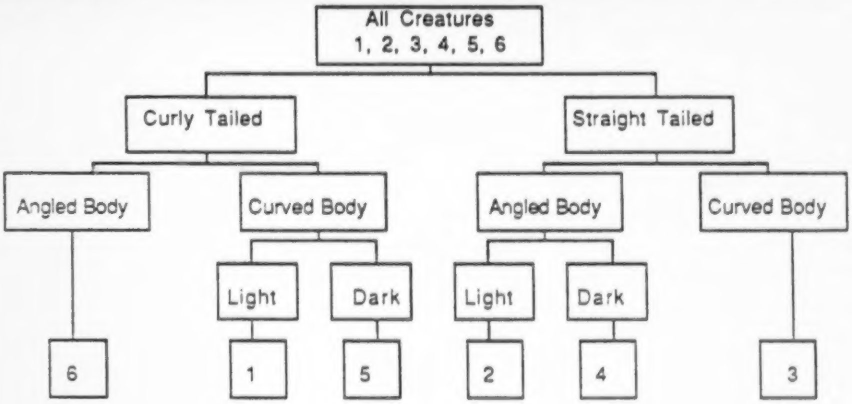
Practice this binary classification skill by playing the "Button Game" with a partner.

1. Think of a rule for grouping the buttons into two sets based on some observable feature.
2. Place the buttons into two groups according to this feature (your rule).
3. Challenge your partner to look at the buttons and guess your rule.
4. When your partner guesses your rule, the partner may think of another rule, group the buttons, and then let you guess the rule.

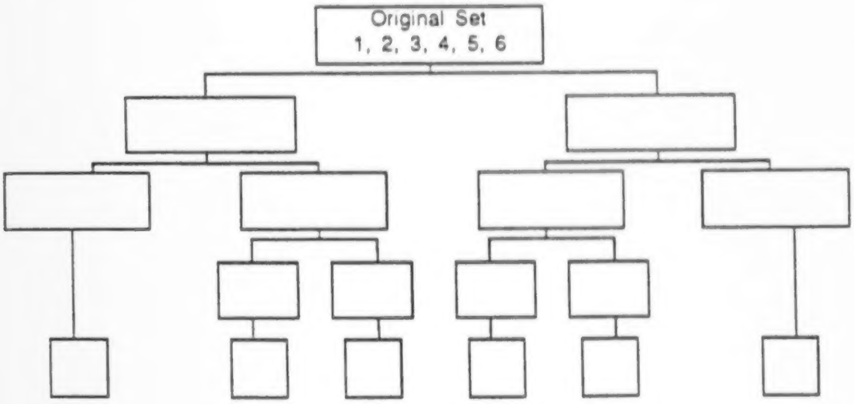
Another scheme for grouping is a multistage classification system in which a set of objects is sorted again and again so that there is a hierarchy of subsets within subsets. As in a binary scheme, subsets are divided into groups by sorting objects that have a particular feature from those that do have that feature.

Since you are familiar with the "wild things", they will be used to illustrate the construction of a multistage classification system. The scheme identifies the observable feature by which the wild things are sorted and each wild thing having that feature is identified.




All Creatures
1, 2, 3, 4, 5, 6
Curly Tailed
Straight Tailed
Angled Body
Curved Body
Angled Body
Curved Body
Light
Dark
Light
Dark
6
1
5
2
4
3

Use the numbered buttons to complete the multistage classification system below. In each box, identify the feature such as color, number of holes, size, etc. that you used to sort the buttons into groups and the number(s) on the bottons which have that characteristic. When the buttons are completely classified, each one will be in a box by itself. You may then identify (name) it.


Original Set
1, 2, 3, 4, 5, 6

According to Funk et al. (1985), a multistage classification system has the following features:

1. Several schemes may be possible depending upon the observable features used for grouping.
2. The scheme is complete when each object in the original set is separated into a box by itself.
3. Listing all the features of a particular object gives a unique description of that object.

REFERENCES

Education Development Center, Elementary Science Study Unit. *Attribute Games and Problems*. New York: Webster Division, McGraw-Hill Book Company, 1968.

Funk, H. James; Fiel, Ronald L.; Okey, James R.; Jaus, Harold H.; and Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Communicating: Activity 4-3

Science is a human endeavor. Without people there is no science. Without communication, science has no value.

To illustrate the above two concepts, play a game called human tic tac toe. You will need two teams of three players, Team A and Team B. The object of the game is to get your team in a straight line on a tic tac toe grid.

Place a large grid on the floor with tape or on the playground with chalk. Number the players on each team. They must move, and must in order, 1A-1B, 2A-2B, 3A-3B, and then repeating until one team forms a straight line as in X's and O's. No one can communicate verbally or nonverbally with each other.

Play the game.

How is this game like science?

Would it help to be able to communicate? Why?

Communicating in science refers to the skill of describing phenomena in order to transmit information and ideas to others. The methods of communication used most frequently in science include graphs, charts, tables, diagrams, maps, symbols, mathematical equations, and visual demonstrations, as well as written and spoken language.

Communication skills need to be developed and practiced in order to be effective, clear, and precise. The purpose of this activity is to learn to communicate ideas, directions, and descriptions effectively.

Materials per participant:

Tangram puzzle
Scissors

Description of Activity:

This activity extends the skills developed in the observing activity by giving participants the opportunity to practice the skill of communicating ideas, directions, and descriptions. Go over the directions for the activity. Work in pairs, to read the explanation and directions, to use the tangram puzzle to construct different figures, and to give precise directions to enable their partners to reproduce the figures. Upon completion of the activity, share the problems encountered in communicating and to suggest solutions to these problems.

Select a partner and match your sets of tangrams to be sure that they are identical. Set up a barrier and construct a design with some or all of your tangram pieces. Then give precise directions to your partner detailing where to place each of the tangram pieces so that your partner is able to exactly duplicate your design. The effectiveness of your communication with your partner can be measured by the degree of similarity between the designs. Repeat this activity a second time to see if your skills of communication improve.

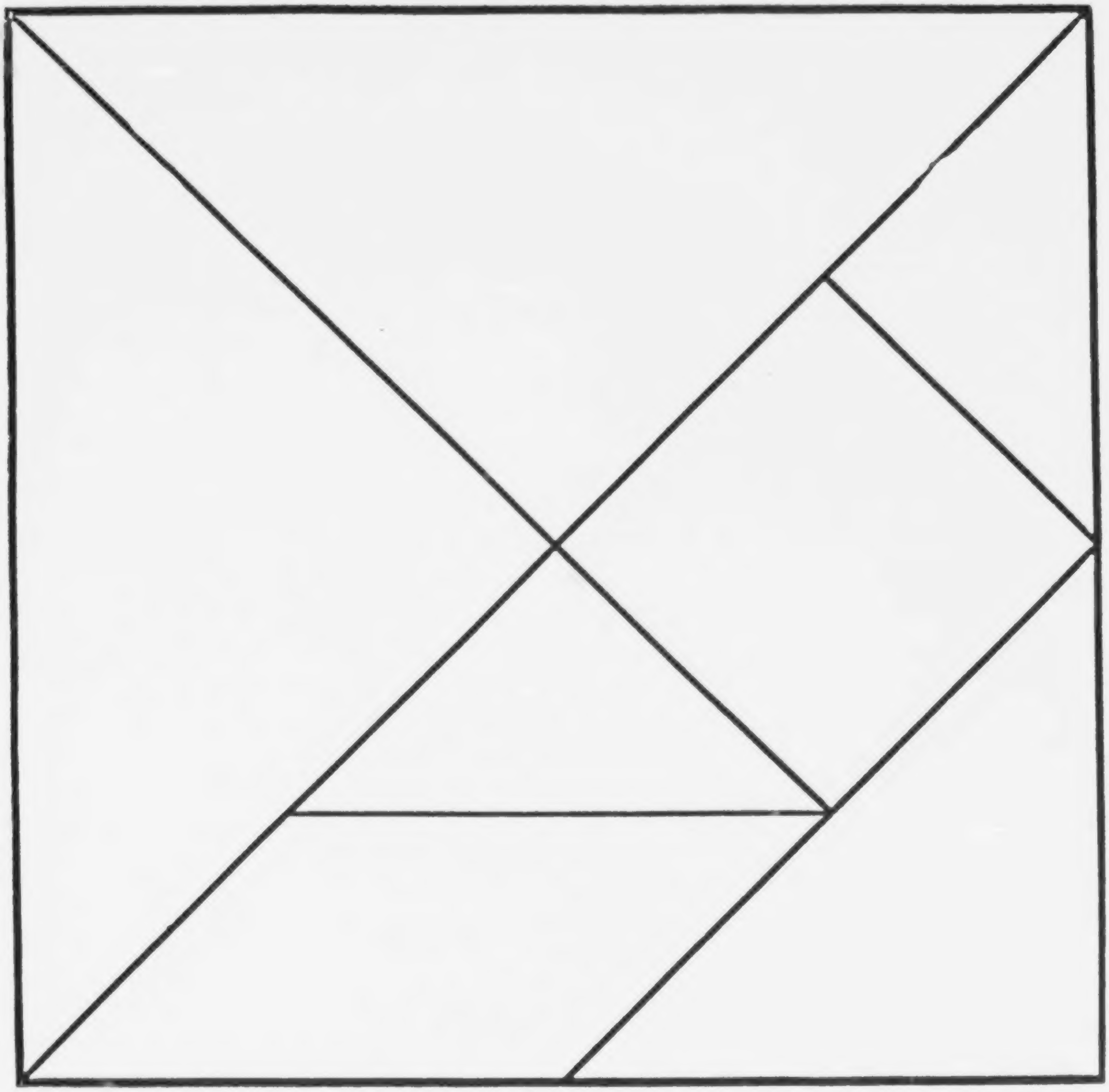
Identify specific areas of giving directions which were troublesome so that you can practice and improve in your communication skills. Use the items that follow as cues for improving communication skills.

1. Only describe what is directly **observed.**
2. Do not make inferences.
3. Use **brief** descriptions.
4. Use **precise** language.
5. Communicated information **accurately** using *qualitative* observations:
6. Provided means for getting **"feedback"** to determine the effectiveness of your communication.
7. Constructed **alternative** descriptions if necessary.
8. Consider other **points of view** and **past experiences.**

REFERENCE

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

TANGRAM PUZZLE



Measuring: Activity 4-4

Measuring is an essential skill in making quantitative observations, comparing objects, and communicating effectively to others. Since the metric system is in base ten, converting units within the system is a relatively easy operation accomplished by multiplying or dividing. Our adoption of the metric system will give us consistency with the countries with which we trade and communicate.

The *meter, liter,* and *kilogram* are the three most commonly used measurements in the metric system. Lengths or distances are measured in meters, volumes are measured in liters, and mass is measured in kilograms. Future conversions might include: "The rancher from Texas is wearing a ten liter hat." and "The Dallas Cowboys play football which is a game of centimeters." Although this may sound strange now, one of the advantages of the metric system is its terminology. Instead of remembering conversions like 12 inches=1 foot=1/3 yards=1/5280 mile, the metric system used prefixes to indicate larger and smaller quantities. By adding the following prefixes to the basic units of measure (meter, liter, and gram), larger and smaller quantities are represented:

METRIC PREFIX	BASIC UNIT	MULTIPLIERS
kilo		1000 times the base unit
hecto		100 times the base unit
deka		10 times the base unit
	meter	
	liter	1 times the base unit
	gram	
deci		.1 of the base unit
centi		.01 of the base unit
milli		.001 of the base unit

Linear Measurement

The basic unit for measuring length in the metric system is the meter; 1 meter equals 100 centimeters. Take your meter tape and observe the centimeter markings; then look around the room and try to select some things which you estimate to be about 10 centimeters, 50 centimeters, and 100 centimeters in length. Use the meter tape to check your estimations.

Materials per pair:

Metric tape measure (refer to participants' instructional materials, 4-4)

Description of Activity:

This activity focuses on familiarizing participants with linear measurement in the metric system. The measurment activities in which participants are directly involved are limited to linear measurement due to possible materials constraints. Go over the directions and examples for each part of the activity. Read the explanation and directions, get the materials, and complete that part of the measurement activity. Upon completion of each part of the activity, share answers. (Refer to the Answer Sheet for Measuring.)

Estimate the following lengths to the nearest centimeter and record them in the column labeled Estimate. Then measure each of the lengths to the nearest centimeter and record the measurements in the column labeled Measurement. After you have completed measuring and recording, convert each centimeter measurement to meters and millimeters. Refer to the meaning of the prefixes on the previous page.

Look at the meter tape and find the millimeter, centimeter, and decimeter marks on it. The *millimeter (mm)* marks are about as wide as the wire in a paper clip and 10 millimeters equal 1 centimeter. The *centimeter (cm)* marks are about the same length as the width of the paper clip or the width of your little finger. The *decimeter (dm)* is a little longer than the width of your hand or about the length of a new piece of chalk and 10 decimeters equal 1 meter. The *dekameter (dkm)* is a measure of length equal to 10 meters. The *hectometer (hm)* is a measure of length equal to 100 meters. The *kilometer (km)* is a measure of length equal to 1000 meters. Using this information, complete the following chart:

Your Metric Measurements

	Estimate	Measurement		
		cm	m	mm
Your height				
Your span (fingertip to fingertip)				
Around your head				
Around your neck				
Length from your wrist to your elbow				
Around your thumb				
Around your wrist				
Length of your little finger				
Around your knee				
Around your ankle				
Length of your foot				

Measure in . . . **If you want to measure . . .**

millimeters____

centimeters____

decimeters____

meters ____

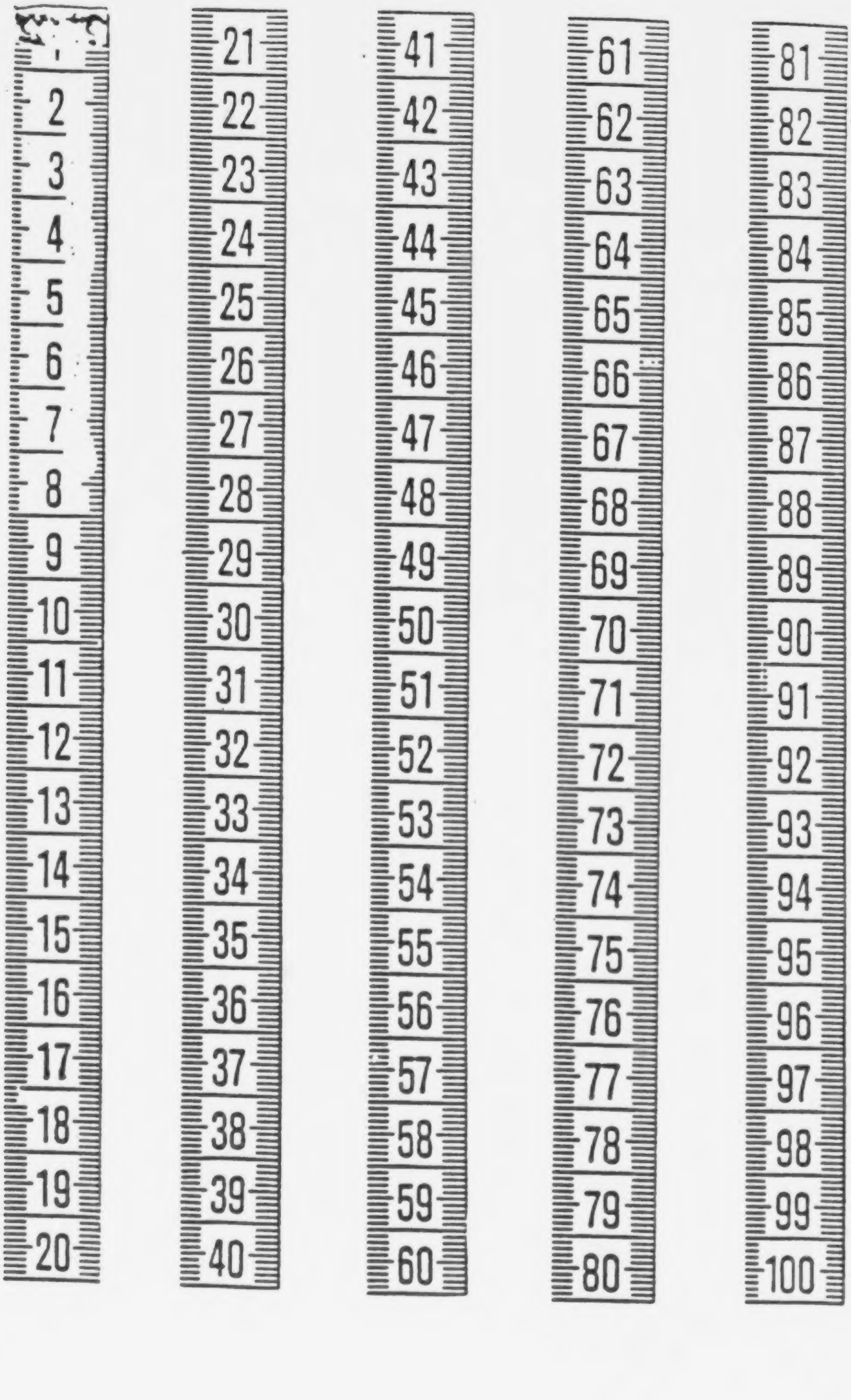
dekameters____

hectometers____

kilometers____

REFERENCE

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.



Inferring: Activity 4-5

Observing is using the senses to collect information about objects and events, while **inferring** is explaining or interpreting an observation. An inference, then, is a conclusion or judgment based on observations but arrived at *indirectly*. An inference depends heavily on experience. For example, if you observe a clear, colorless, odorless liquid, you *infer* that it is water. Although you have not experienced this directly by tasting the liquid, you base this inference on your observations that the liquid is clear, colorless, and odorless. You can test your inference by actually tasting the liquid to observe if it tastes like water. Obviously, every inference must be based on direct observation. When we are able to interpret and explain things happening around us, we have a better appreciation of our environment. Much of our behavior is based on the inferences we make about objects and events as we learn to recognize patterns and to expect these patterns to reoccur under the same conditions. Hypotheses are based on the inferences scientists make during their investigations. In this activity, you will develop skills necessary to make appropriate inferences based on observations about objects inside sealed containers.

Materials per pair:

Small cardboard box with an object or objects inside. Suggested objects: several nuts and washers, steel wool soap pad, marble or marbles, blocks of wood, folded 3 x 5 card, 2 or 3 wooden dowels, B-Bs, rubber stopper, macaroni, black walnut, piece of chalk, checker, sponge, coin, cotton ball

NOTE: If you are doing this activity on your own, you will need to have someone else make up a few "mystery boxes" for you.

Description of Activity:

The purpose of this activity is to help participants make inferences. The activity is set up so that observations are made first; then inferences are made based upon the observations. Make sure that the participants understand that an inference is a conclusion or judgment based upon an observation and that is arrived at indirectly rather than directly. Go over the directions and examples for each part of the activity. Work in pairs to read the explanation and directions, get the materials, and complete that part of the activity. Upon completion of each part of the activity, share observations and inferences. (Refer to the Answer Sheet for Inferring.)

Obtain a mystery box. Do not open the box or directly touch the contents. Make at least five observations about the object(s) in the box and derive an inference based on each observation. You may tilt, shake, roll, or rattle the box but do not look inside. List your observations and inferences on the lines that follow.

OBSERVATIONS	INFERENCES
1.	
2.	
3.	
4.	
5.	

Now take off the lid of the box and, without peeking inside, put your hand in the box and gather some additional information about the contents. Accept, reject, or change each of your original inferences on the basis of new information on the lines below. Be sure to identify the observation on which you accept, reject, or change each inference.

OBSERVATIONS	INFERENCES
1.	
2.	
3.	
4.	
5.	

REFERENCES

Cain, Sandra E. and Evans, Jack M. SCIENCING: *An Involvement Approach to Elementary Science Methods, 2nd Ed.* Columbus, Ohio: Charles E. Merrill Publishing Company, 1984.

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, ConstanceStewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Defining Operationally: Activity 4-5

In our society, specialized groups, from nuclear physicists to punkers, develop their own "jargon". The meanings of existing words are changed by such groups to express entirely different ideas than the traditional definitions. In this context of communication and change, defining operationally takes on significance as a process skill. In defining operationally, the students will be expected to explain objects and events in the context of their own experiences.

It is possible for different investigators to use different operational definitions for the same variable since it is a made-up definition. For example, suppose an investigation was being conducted to test the effects of "amount of exercise" on a person's pulse rate. The manipulated variable "amount of exercise" could be defined many different ways:

a. the number of sit-ups done
b. the distance jogged
c. the number of laps swum

Physical and biological sciences impose somewhat different criteria in formulating an operational definition. For biologists, operational definitions are descriptive. One example of an operational definition of bronchi might be:

Two breathing tubes that branch out of the trachea and lead to the lungs.

Physical scientists, on the other hand, state operational definitions in terms of "what you do" and "what you observe." For example, an operational definition of baking soda might be:

An indicator of acid that will fizz (what you observe) when liquid acid is placed (what you do) on it.

This difference in the operational definitions for the biological and physical sciences should be noted. In a number of situations in elementary school science, a descriptive definition is adequate. If possible, however, operational definitions should include **what is done** and **what is observed.**

Consider this case in order to think of a variety of ways that a variable might be operationally defined. If you are an expert in horticulture and you are growing beans in an experiment, you need to operationally define the variable "amount of plant growth". List three different ways that you could operationally define this variable by thinking of three different approaches for measuring how much the plant grew.

1.

2.

3.

Possible answers follow on the next page.

Possible Answers
Defining Operationally: Activity 4-5

Write down three different ways that you could operationally define this variable. Just think of three different ways you could measure how much the plant grew.

Answers will vary. Some possible answers are:

1. Count the number of leaves on a plant. Wait two weeks and count them again.
2. Measure the distance from the soil to the uppermost leaf. Ten days later, measure it again.
3. Measure the distance from the soil to the top of the plant. Seven days later, measure it again.

REFERENCES

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Brown, William R. *Handbook of Science Process Activities.* Worthington, Ohio: Education Associates, Inc., 1974.

Investigating: Activity 4-6

Investigating is a science process that may include a number of other skills. Usually, an investigation begins with a problem or question stated in the form of a hypothesis. Often a hypothesis is defined as an educated guess. A better definition would be: a hypothesis is an educated question in search of an answer; you get the answer by conducting an experiment. If the results of the experiment confirm the hypothesis, it is accepted. If they do not, then the hypothesis is rejected.

The following factors are common components in doing an investigation:

- a problem statement - ask a question.
- state a hypothesis - put the question in the form of an if-then statement.
- a design - operational definitions of the if-then variables may be helpful, how you will control variables, and a procedure.
- data collection - report quantifiable data in a table.
- data interpretation - relationships between if-then variables, graphs are a great help.
- hypothesis acceptance or rejection - how do the findings compare with the hypothesis?

In a well-designed experiment, these questions should get a "Yes" answer:

1. Have you identified your if variable?
2. Have you identified your then variable?
3. Have you identified other variables that may affect your experiment?
4. Does your experiment control these other variables?
5. Do you have a detailed plan of how to do your experiment?
6. Can you get the materials you will need for your experiment?
7. Can you get quantitative data from your experiment?
8. Have you planned a way to record your data?
9. Did you organize your data so you could analyze it?
10. Did you decide if your data supports your hypothesis?
11. Can you think of ways to improve your experiment?
12. Did you record any new questions that you thought of while doing this experiment?

Sample Investigation

1. Problem: How does the temperature of water influence how fast a sugar cube dissolves?
2. Hypothesis: If the temperature of water is increased, then a sugar cube will dissolve faster.
3. Design:
   "If" variable: Water temperature.

Values of the "If" variable: 10 degrees C, 30 degrees C, 50 degrees C, 70 degrees C, 90 degrees C.

"Then" variable: Length of time it takes a sugar cube to dissolve.

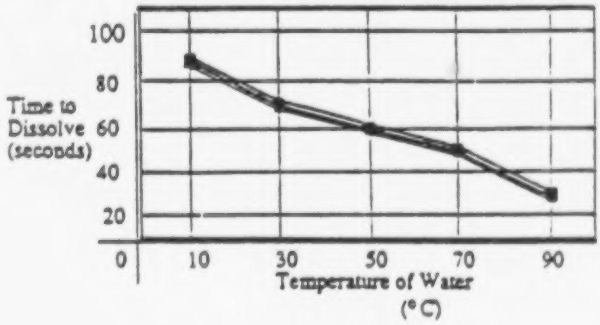
Controlled Variables: Amount of water, size of sugar cube used, kind of containers used, kind of stirring rod used, and the manner of stirring.

Procedure: The manipulated variable of differing temperatures of water (10 degrees C, 30 degrees C, 50 degrees C, 70 degrees C, and 90 degrees C) will be measured and a sugar cube will be placed in identical containers each holding 250 milliliters of water. The water will be stirred until no more sugar crystals are observed and the length of time it takes the sugar to disappear will be the responding variable recorded. Controlling the amount of all the water, size of sugar cube used, and the manner of stirring will prevent other variables from affecting the outcome.

DATA COLLECTION

Temp. of water (degrees C)	Time to dissolve (seconds)
10	87
30	75
50	60
70	52
90	35

DATA INTERPRETATION



Relationship Observed Between the Variables: The greater the temperature of the water, the shorter the time it takes the sugar cube to dissolve.

Findings: The investigation supported the hypothesis.

Materials per pair:

rubberband, paper clip, 6 washers, metric tape measure (Refer to participants' instructional materials 4-4), pencil (supplied by participants), roll of masking tape (used for securing pencil to table)

Description of Activity:

The participants work in pairs to design and conduct an experiment to answer the question, "Does the amount of weight added to a rubberband affect the length a rubberband will stretch?" Read the explanation and directions and conduct the investigation. Upon completion of the experiment, share hypotheses, designs, relationships observed between the variables, and findings.

Investigation for Experimenting

1. Problem: Does the amount of weight added to a rubberband affect the length that the rubberband will stretch?

2. Hypothesis: ______________________________

____

____

____

3. Design "If" Variable: ______________________________

____

Values of the "If" Variable:.______________________________

____

____

____

"Then" Variable: ______________________________

____

____

____

Controlled Variables: ______________________________

____

____

____

Procedure:

4. Data Table:

5. Graph:

6. Relationship Observed Between the Variables:______________________________

____

____

7. Findings: ____

____

____

Possible Answers
Investigating: Activity 4-6

Answers will vary.

1. Problem: Does the amount of weight added to a rubberband affect the length that the rubberband will stretch.

2. Hypothesis: The greater the amount of weight added to a rubberband, the greater the amount the rubberband stretches.

3. Design:
Manipulated Variable: Number of washers (weight) added to rubberband.

Values of the Manipulated Variable: 1-6 washers

Responding Variable: Length the rubberband stretches

Controlled Variables: Same location, rubberband, paperclip, weight of each washer, and measuring instrument.

Procedure: Suspend the rubberband from a pencil secured to the table with masking tape. Using a hook shaped from a paperclip, hang a washer on the rubberband. Measure the distance from where the rubberband is suspended to the paperclip hook. Continue adding washers to the hook one at a time until a total of six washers are hanging from the rubberband. After each addition, measure the distance between suspension and hook. Using the same rubberband during all measurements will prevent other variables from affecting the outcome.

4. Data Table:

No. of Washer	Length of Rubberband
1	Answers will vary.
2	
3	
4	
5	
6	

5. Graph

6. Relationship Observed Between the Variables: The greater the amount of weight added to a rubberband, the greater the amount that the rubberband stretches.

7. Findings: The investigation supported the hypothesis.

REFERENCE

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Predicting: Activity 4-7

A prediction is a forecast of future events or conditions based upon data interpretation. Our behavior towards our environment is guided by the ability to make reliable predictions about objects and events. Predicting is closely related to observing, inferring, classifying, and hypothesis testing. Predictions should be based on careful data interpretations which are supported by repeatable experiences. Classifying helps us to recognize patterns and to predict from those patterns what future events might be.

Materials per pair:

Container, 50 1" x 1" tagboard squares (25 red, 10 blue, 10 green, & 5 yellow)

Description:

This activity involves the participants in the process of predicting. It is important that the participants understand that predicting is not the same as guessing; predictions are made based on selected data. Go over the directions and examples for each part of the activity. Direct the participants to work in pairs to read the explanation and directions, get the materials, and complete that part of the prediction activity. Upon completion of each part of the activity, ask the different pairs to share the rationale for their predictions.

One of the factors that can affect the accuracy of a prediction is chance. In this activity, you will learn to make predictions based on the total population of a container of fifty (50) tagboard squares and to test your predictions for reliability. Get a container of fifty (50) 1" x 1" tagboard squares and count the squares to make sure that there are 25 red, 10 blue, 10 green, and 5 yellow squares. Since all the squares are alike except for color, each square has the same chance to be picked as any other square (if taken without peeking). If you were to pick a sample of half (25) of all the squares from the container, predict how many of each color would be in this sample.

PREDICTIONS

Red =________

Blue =________

Green =________

Yellow =________

Test your predictions by picking 25 squares from the container to see how they actually compare with your predicted sample.

ACTUAL

Red =________

Blue =________

Green =________

Yellow =________

If a population is very large or scattered over a wide area, it may be impossible to take a sample of half of the entire population. In situations such as this, scientists take many small samples. If you were to pick a small sample of ten squares from the container, you would have taken 1/5 of all the squares. How many red, blue, green, and yellow squares would you predict to be in the sample? Enter your predictions in the table below beside *Predicted Sample*. Then take ten squares from the container and enter the actual number of red, blue, green, and yellow squares beside *Actual Sample*.

SQUARES	RED	BLUE	GREEN	YELLOW
Predicted Sample				
Actual Sample				

You are probably satisfied with the accuracy of your prediction and your "confidence" is high if the predicted numbers were close to what you actually picked in your sample. If your prediction was not close to what you picked in your sample, you might want to try it again. Since chance played a part in which squares were selected in the sample, it accounts for any differences noted.

We can find out if the number of samples affects the accuracy of a prediction by taking five separate samples and checking to see how closely the actual samples compare with the predicted sample. Reach into the container and take a sample of ten squares without peeking. Under the column labeled *Sample 1*, record the number of **red, blue, green,** and **yellow** squares. Be sure to return the squares to the container and mix them with the other squares before repeating the procedure of picking another sample.

SAMPLE	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	TOTAL OF SAMPLES	TOTAL POPULATION
RED							
BLUE							
GREEN							
YELLOW							

Total the number of red squares in all five samples and record that number under *total of samples* for **red**. Repeat this procedure for the **blue, green,** and **yellow** samples.

How close was your *total of samples* to predicting the entire population of squares?

____

Were your answers closer, farther from, or about the same in predicting the correct amounts of red, green, blue, and yellow square? ________________________________

____

____

Why did your answers differ?____

____

____

What do you think would happen to the accuracy of your prediction if you took ten samples instead of five?____

____

____

REFERENCE

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. *Learning Science Process Skills, 2nd Ed.* Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Possible Answers
Predicting: Activity 4-7

PREDICTIONS

Red = 12 or 13

Blue = 5

Green = 5

Yellow = 2 or 3

Test your predictions by picking 25 squares from the container to see how they actually compare with your predicted sample.

ACTUAL

Answers will vary.

Red =________

Blue =________

Green =________

Yellow =________

SQUARES	RED	BLUE	GREEN	YELLOW
Predicted Sample	5	2	2	1
Actual Sample	Answers will vary.			

SAMPLE	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	TOTAL OF SAMPLES	TOTAL POPULATION
RED							25
BLUE							10
GREEN							10
YELLOW							5

Total the number of red squares taken in all five samples and record that number under *total of samples* for **red**. Repeat this procedure for the **blue**, **green**, and **yellow** samples.

How close was your *total of samples* to predicting the entire population of squares? Answers will vary but totals should be fairly accurate.

Were your answers closer, farther from, or about the same in predicting the correct amounts of red, green, blue, and yellow squares? Answers will vary but should be closer to the actual number of red squares because of the greater number of red squares.

Why did your answers differ? Chance played a part in which squares were selected in the actual results.

What do you think would happen to the accuracy of your prediction if you took ten samples instead of five? The accuracy would be better and confidence would be higher.

REFERENCE

Funk, H. James, Field, Ronald L.; Okey, James R.; Jaus, Harold R.; & Sprague, Constance Stewart. Learning Science Process Skills, 2nd Ed.Dubuque, Iowa: Kendall/Hunt Publishing Company, 1985.

Creating: Activity 4-8

You can't make something from nothing. To create, you need intelligence and stuff. The steps in the creative process are as follows:

Step 1. Challenge to the Imagination

Little children are naturally creative. If you place beads, string, and tape on a table near kindergarteners, they will immediately interact with the stuff and create something. Older children and adults seem more reserved. For many, the challenge to the imagination must be extrinsic. The teacher may need to ask, "I wonder what we could make with these things?"

Step 2. Incubation

Once challenged, the mind should have time to incubate, to mull the challenge over. In groups, brainstorming is a great aid to incubation. No one of us is as smart as all of us.

It is very helpful to write down details for the creation. In effect, a recipe helps. Few curricula or classroom situations allow much thinking time.

Step 3. Do it

Physically create what has been mentally planned.

Step 4. Evaluation

Criteria for evaluation will vary with the product.

Materials:

Unknown at this point.

Description of Activity:

The purpose of this activity is to create a chocolate cake. You may not refer to an existing recipe.

Step 1. Challenge to the Imagination

Your challenge is extrinsic. I have challenged you to create a chocolate cake.

Step 2. Incubation

This is think time. List factors you should consider in creating the cake. They may range from ingredients/amounts to oven temperature. Write out your recipe.

Step 3. Do it

Make the cake.

Step 4. Evaluation

Eat the cake. Revise your recipe if appropriate.

REFERENCES

Herbert, D. Mr. Wizard's Supermarket Science. Random House, NY, 1980.

Cobb, Vicki. Science Experiments You Can Eat. J. B. Lippincott Company, Philadelphia, 1972.

Chapter 5

SCIENCE, TECHNOLOGY, AND SOCIETY

What is STS? (Component 4.1)

Worldwide there is concern for a modernized school curriculum. Impetus for this concern in developed countries centers on maintaining world leadership. In less developed countries, the concern centers on improving their status. All see science and technology as a major factor in survival.

In the United States, there has been a significant push for a new vision of science education designed to help maintain our quality of life and position as a world leader.

There is no question about how important a role science and technology play in our lives. Over the past decade, it has become increasingly evident that we have moved into a new and radically different phase of history with science and technology serving as major driving forces. Most existing science curricula fail to reflect the realities of modern society. As presented, science and social studies fail to deal with modern cultural issues and the impact of science and technology. What is needed is a curriculum that is related to human welfare, social progress, and civil responsibilities. The product of education should be students who are literate about the roles of science and technology in their own lives and in the global situation.

Important Points (Component 4.1)

1. Science and technology are no longer distinct enterprises. They operate as an integrated system. Traditional science programs do not operate this way.
2. The traditional concept of a scientific method no longer exists. Research is done by teams of experts from many fields. Success depends as much on social interactions and access to computerized information systems as it does on the science skills of the investigators.
3. Most scientific research today is oriented toward problems of human, material, or global welfare rather than on advancing new theories. Social and economic factors have more impact on science than reason and observation. This is not the image of science found in textbooks.
4. The traditional disciplines of biology, geology, chemistry, and physics are modeled after science activities carried out in the early 1800's. These disciplines have little meaning in modern science. Today, science is characterized by problems being researched such as fiber optics, or seismic forecasting, rather than by disciplines.
5. Technology concepts and reasoning processes are missing in most school curricula. Students who are illiterate concerning the interaction of science, technology, and society will probably live unfulfilled lives in a society that they do not have the skills and under standing to be a part of - they become The Third World Within.

Why STS? (Component 4.1)

The most frequent recommendation made in education reform reports is that technology concepts and reasoning processes be integrated into the curriculum. Technology can be used to bridge the gap between science and society and link science with the affairs of life. The thinking processes typical of technological endeavors resemble those that people need for resolving personal and social problems occuring in everyday living.

A modern science-social studies program should:

- increase student's ability analyze issues that arise in our technological society.
- increase the socio-scientific reasoning ability of students.
- develop student's higher-order thinking skills, including problem-solving, descision-making, and critical analysis/thinking.
- develop student's awareness of their role in the process of technological change.
- help students recognize the complexity of decision-making in our high-tech world.
- provide opportunities for students to examine possible future technologies brought about by advances in science, engineering, and societal changes.

Expanding Scientific Literacy to STS Literacy (Component 4.1)

Earlier, scientific literacy was presented as consisting of concept, comprehension, application, and attitude components with respect to the concepts of science. If science is to include technology and society, then the definition of scientific literacy must also be expanded.

Concept level remains unchanged. Written or verbal language symbols call to mind concepts in all areas. Comprehension level also remains basically the same. The facts that are put into language still indicate our understanding of a concept. These facts should provide reasonable explanation for observed relationships. The facts should be based on the kind of evidence that most people would agree upon.

The application level also remains basically unchanged. The science process skills are appropriate methods of obtaining information and solving problems in most real-life situations. These processes include:

Observing and describing
Classifying and organizing
Measuring and charting
Communicating
Predicting and inferring
Hypothesizing
Hypothesis testing
Identifying and controlling variables
Interpreting data

For the purpose of better defining STS literacy, it seems appropriate to pull creating out of the earlier list of process skills and elevate imagining and creating to the status of a new major category. We call this the creativity level. Creativity level of STS literacy refers to attributes of behavior such as curiosity, questioning, explaining, and inventing. In the STS curriculum, this component of literacy is referred to under techology as process. Some of the human abilities important in this domain are:

Visualizing - producing mental images
Combining objects and ideas in new ways
Producing alternate or unusual uses for objects
Solving problems and puzzles
Fantasizing
Pretending
Dreaming
Designing devices and machines
Producing unusual ideas

Much research and development have been done on developing students' abilities in this creative domain, but little has been purposely incorporated into social studies or science programs.

The attitude component of literacy remains essentially unchanged. The scientific literacy explanation of attitude level emphasized student success and enjoyment. These are important aspects, but may be expanded in STS literacy to include other human feelings, values, and decision-making skills that relate to complex social and political situations, environmental and energy-related factors, and general feelings about the future. This domain includes:

Developing positive attitudes toward science and society in general and toward oneself (an "I can do it" attitude).
Exploring human emotions.
Developing sensitivity to, and **respect** for, the feelings of other people.
Expressing personal feelings in a constructive way.
Making decisions about personal values.
Making decisions about social and environmental concerns.

Another component that needs to be considered in STS litercy is a person's integration level. This refers to ones ability to "see" the big picture. This is the connections and consequences domain. A major purpose of STS education is to include a substantial amount of information, skills, and attitudes that can be transferred and used in real-life situations. Some dimensions of this component are:

Seeing instances of scientific concepts in everyday life experiences.
Applying learned science concepts and skills to everyday technological problems.
Understanding scientific and technological principles involved in household technoligical devices.
Using scientific processes in solving problems that occur in everyday life.
Understanding and **evaluating** mass media reports of scientific developments.
Making decisions related to personal health, nutrition, and life style based on knowledge of scientific concepts rather on "hear-say" or emotions.
Integrating science with other subjects.

In summary, STS literacy consists of:
Concept Level
Comprehension Level
Application Level
Creativity Level
Attitude Level
Integration Level

For example, the language symbol "presticide" calls to mind some concept level of STS literacy. I can assess your comprehension level with respect to "presticide" by conducting a conversation and questioning session. Your application level may be demonstrated by doing experiments on weeds with a herbicide. Creativity level may consist of identifying new natural herbicides found in bacteria cultures. Attitude level would be reflected in a person's willingness to use pesticides and integration level might include an appreciation for the impact spraying weeds in a watershed might have on ground water quality.

For every STS concept, an individual would have a literacy profile that includes six components.

Technology as Product and Process (Component 4.1, 4.2)

Technology as a product includes both "hard" and "soft" technologies. Hard technology includes the tools developed for the use of people. This ranges from the first crude weapons and tools of primative people to the most modern computer. Soft technology includes the systems involved in the development and uses of technological devices, as well as the systems involved in solving problems in industry and society.

Appropriate technology refers to that process or product best suited to a given situation.

Technology as a process is closely related to creativity. Technology as a process is expanded below into subcomponents.

A. Challenge to the Imagination

The key to initiating the creative process is "seeing" a problem. The kindergarten child with the string, button, and bead automatically asks, "What can I make with these." Unfortunately, this automatic response has been trained-out of older people. By third grade, we all stay within the lines. Often, older children need extrinsic motivation to "see" a problem. A major goal of education should be to maintain intrinsic motivation for creativity.

B. Incubation and/or Planning

A mental process is initiated in step one above. Somewhere early in the process, the challenge is mentally transformed into a verbal or written statement. The statement becomes the basis for an extended thinking-planning process. Some major ideas may incubate in the back of the mind for days, weeks, or even years. This stage in the total process is critical. Incubation time must be provided. Research indicates that even seconds make a difference in student response. Think what days or weeks might do.

Some students may be more adept at "seeing" a problem, others may contribute significantly to providing ideas, alternative approaches, or solutions. Brainstormed ideas should be recorded and analyzed. All ideas are not of equal worth. However, a value judgment usually cannot be made intuitively. Judgments should be made on the basis of information. Again, the analysis-information gathering component requires time. If second grade children are inventing a chocolate cake, properties of flour, water, baking powder, eggs, and chocolate need to be investigated at some length. These studies may require weeks of work before a final plan (recipe) is ready.

Alternative solutions or ideas need to be spelled out in some detail. In the cake example above, do you combine dry ingredients first, or do you add the liquid to the flour before adding baking powder, sugar, and salt. Exploring alternatives should result in an optimum plan that is cost effective in time and money, manageable, safe, and have a high probability of being successful. The plan must be detailed. All steps and ingredients must be specified. Drawings may be required.

C. Do it

The optimum plan (working plan) is the transition from the incubation stage to the do it stage. The do it stage is where what has been mentally planned is physically created. You bake the cake.

The product of the do it stage is the prototype.

D. Evaluation

The prototype must be evaluated. Criteria for evaluation will depend on the product. Criteria for a chocolate cake will be different from criteria for a new can opener. In every case, criteria should be specified. Criteria may reflect consumer needs or preferences, manufacturers concerns, environmental impact concerns, aesthetic considerations, and general performance. Does the product do what it was intended to do? Does it answer the question or solve the problem?

The prototype should be modified to reflect evaluation concerns and then re-evaluated. Status of the prototype should be summarized in a final report that summarizes all of the steps to this point.

Implementation, manufacture, and marketing are normal follow-up components

Life With a Professor (Component 4.3)

One of the outstanding aspects of the science methods course has been the dedicated service of faculty interested enough in elementary science to devote 10-20 hours to a small group of methods course students. These professors come from various colleges and departments; however, their function is identical. They provide the students with a mentor-scientist xperience in which the student can investigate a science, technology, and society issue. Tis investigation is carried out over a period of about six weeks.

STS Approach to Curriculum (Component 4.1, 4.2)

The activities that follow are designed to acquaint the student with the STS approach to curriculum. The approach utilizes background information, videos from "The Challenge of the Unknown"*, and hands-on assignments and activities.

Step 1. STS Real-Life Situations

Materials:

"Situation" and "Information" sections of The Challenge of theUnknown video.

Description of Activity:

The text that follows and video are intended as basis for interactions that promote an understanding of STS and illustrate potential curriculum ties.

Their are some important aspects of identifying the role of science, technology, and society in a problem-solving situation. They include:

> 1. Developing a clear picture of the problem situation. Good problem solvers try to have an understanding of all of the factors that may impact a situation.
>
> 2. Identifying patterns. Factor analysis may remind you of other problems you have previously solved. Not recognizing a problem alerts a person to the fact that a situation presents a new problem. These circumstances may initiate the creative process, hypothesis formation, or technology as a process.
>
> 3. Establish or describe relevant goals, rules, conditions, or limits. A goal points in the general direction of a solution; rules of limits place certain parts of theterrain out of bounds. By describing the conditions of the problem situation, the problem solver takes a bearing in preparation for heading off on the solution process. Without goals, limits and initial bearings, the problem solver might stay stuck in the situation with no way to get out.

---

* The Challenge of the Unknown - For information, contact: Phillips Petroleum Company Educational Films, 16-B4, PB, Bartlesville, OK 74004.

To help sharpen problem-defining skills, do the following:

1. Describe the following "situations":

   - Do the doors of your bedroom open in or out?
   - What color is the inside of your refrigerator?
   - Where is the sun in the sky at mid-day?
   - Stand up and turn to face the direction of your home.
   - Which shoe do you put on first?
   - When you cross your arms, which arm is on top?

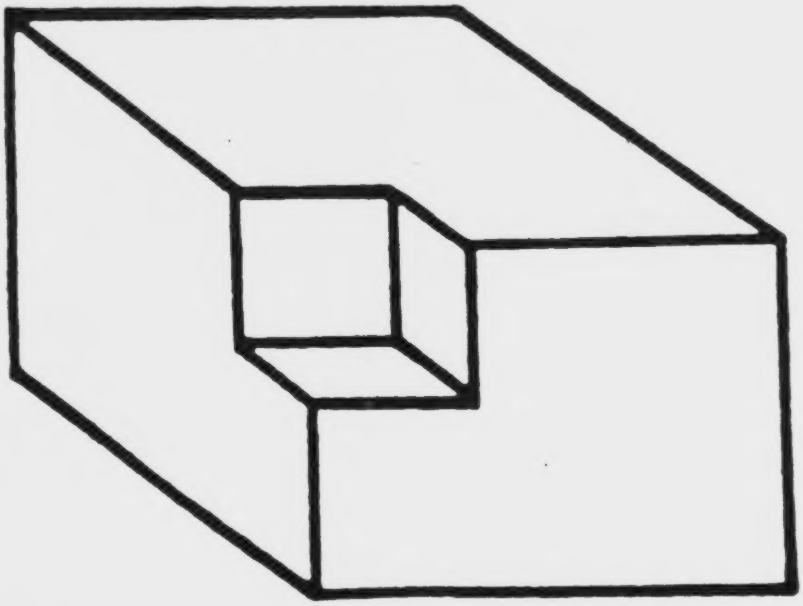
Identifying or diagnosing the underlying components in a situation can be a problem in itself. Wavy lines on a TV are symptoms. A good repair person would want to know the whole situation--how old the set is, what repairs have been done in the past, what the reception is normally like, whether the television has an antenna or cable, or whether it has been moved recently to a different part of the house, etc.

2. Describe what you would want to know in order to have a clear picture of each problem situation.

   - a lamp that won't light
   - an alarm clock that rings an hour too early
   - a paper airplane that won't fly

   Appreciating the situation means getting a big picture of the problem.

3. The drawing below can be interpreted as at least three different three-dimensional shapes. Can you describe all three?



The "For Openers" section that follows is designed to introduce you to the "Situation" video. Answer questions 1-3 and look over 4-A, B, C, D before viewing the video.

FOR OPENERS

The questions below are designed to help you get a feel for situation problem solving before and as you view the film.

1. What is a problem situation? What makes it important?

2. What are the kinds of problem situations you face in daily life? How do you analyze them?

3. How might your problem-solving approach depend on the situation?

4. In what ways is situation particularly important to the characters in the film?

   A. Situation is extremely important in the sport of orienteering. What do contestants like Rebecca Frawley do to make the most of it?

   B. What is the situation that wind prospector Eliza Dixon works with? On what does she base her decisions?

   C. How does Dale Eldred use a situation to create a work of art? How does his art depend on the situation?

   D. In what situation does "Buzhnikov the Doorman" find himself? Does he deal with it successfully?

Now that you have viewed the "Situation" film, let's discuss problem solving and STS interactions. The first situation in the film is about orienteering. What are the components of problem solving involved in orienteering?

The specific problem in orienteering is getting from one point to another. In order to do that, you must assess the situation. Such an assessment includes the science process skills of observing, interpreting, and measuring. The technology involved is the compass, map, and map reading. The entire experience is a social experience. What are the STS aspects of Eliza Dixon's situation?

I might describe Minneapolis as a large midwestern city with cold winters and a lot of lakes. How would Dale Eldred describe it?

Every person has a different perspective on a problem. Eldred emphasizes sunlight and shadow, where the sun falls and where the shadow line is. Is this situation science? Is this situation technology, is it art, is it society?

STS Assignment #1

Step 1. Challenge to the Imagination

Most textbook problems come already defined. Real world problems occur in a matrix of events and things that may obscure both the problem and the solution. For your assignment, identify a real life problem. Then assess the problem situation. List factors that might influence both the problem and the solution process. Discuss how your problem includes aspects of science, technology, and society.

Step 2. Impact of Information

We live in an information age. Computers, books, newspapers, radio, televisions, phones, memos, magazines, circulars, brochures, and addresses are constant companions. Sorting and interpreting information is critical in effective problem solving.

Mathematics provides the problem solver with powerful tools to sort and analyze information. Formulas, graphs, and equations are among the many mathematical tools that can be employed to break down information that might not easily lend itself to analysis in any other way. In many cases, mathematics provides the problem solver with the means to simplify a problem so that patterns and relationships can be identified and a solution found more readily.

Where mathematics can serve to **simplify** an information-rich environment, computers and other products of this technological age allow you to collect, assemble, and analyze data in quantities and with a precision that dazzles the mind.

In whatever form it is used, **quantification** is one of the most basic and powerful tools at your disposal. It allows you, quite literally, to compare apples and oranges, at least in numerical terms such as weight, density, nutritional value, and caloric content.

Here are some of the rules of the road for problem-solving detectives who need to sort through and manage information.

Too much information can obscure a problem. Weed out extraneous information until all that remains is essential to finding a solution. For each piece of information, ask the question: Is this leading me toward or away from a solution?

Too little information can hold up the problem-solving process. Pinpoint as closely as possible what additional information is needed and how best to find it.

Test information for reliability. Don't take it for granted that all information comes from a valid and viable source. Test its pedigree. Who says it's true, anyway?

Information loses meaning out of context. A single clue abstracted from the scene of a crime loses value. Where a piece of information comes from in relation to others is itself valuable information.

Marshall facts. With the needed information in hand, analysis can begin. When the pieces of the puzzle are assembled, patterns emerge which point in the direction of a solution. If difficulties arise, the problem solver must try to put the information in some other form that might make it easier to see a pattern - a table or a graph or a chart of some sort, for instance. Does any one piece of data stand out? Does that fact, or any other, invalidate the rest? Check the sources again. Is the analysis persuasive? Will it convince others?

In the exercises that follow, you will be challenged with activities that will help clarify the role of information in STS problem solving.

Think about the following:

It is a rare occasion when you have all the information you need to solve a problem. When something is missing, how do you find it?

The answer depends on what you are looking for. If you want to know what the average winter temperature in Los Angeles is, the encyclopedia will supply the answer. If the question is, "Why don't I have more dates?", the encyclopedia will be of little help in obtaining the answer.

You will now view a film on "Information". Answer the first two questions on the page that follows and go over the parts of question 3 to prime yourself for watching the film.

“Information” Preview

1. How is information important in solving problems?

2. In your daily life, what kinds of information are important to you? What kinds of information are important to your parents? How and why might they differ? In what areas might they be the same?

3. What kinds of information do the people in the film use to solve their problems?

A. How is information at the root of “Bill the Hoofer’s” problem in the comedy segment?

B. How do ice climbers depend upon information to keep their footing on ever-changing spires of ice?

C. There is little information about the long-lost Anasazi Indians except the ruins and relics they left behind. Is that unusual? How do we usually learn about people who lived centuries ago?

D. How does Paul Hamilton, the engineer in the segment about speed skiing, use information? To what end?

E. In the segment about Norwegian fishermen, what does the film mean when it says their problem is "too much information?"

F. What impacts do science and technology have on past and present societies? Give specific examples from the film.

G. For each of the film episodes, list the related components of science, technology, and society.

Bill Hoofer

Science

Technology

Society

Ice Climbers

Science

Technology

Society

Anasazi Indians

Science

Technology

Society

Skiing

Science

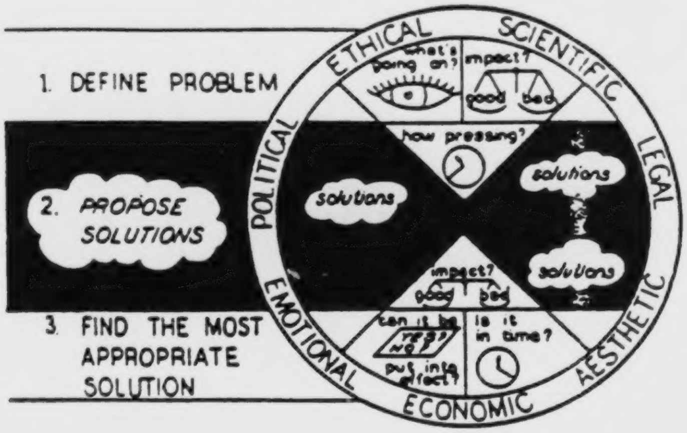
Technology

Society

The Norwegian fishing component of the film includes all of the major components of an STS problem. STS problems are complex and difficult to structure. The three-step model presented below uses an interdisciplinary science and social studies perspective to solve STS problems. Working through data collection and analysis should aid in identifying the impacts of the problem and trade-offs needed to come up with a solution that balances societal and environmental concerns.

STS problems are complex and difficult to structure. The three-step model presented below uses an interdisciplinary science and social studies perspective to solve STS problems. Working through data collection and analysis should aid in identifying the impacts of the problem and trade-offs needed to come up with a solution that balances societal and environmental concerns.

THE PROBLEM-SOLVING MODEL


1. DEFINE PROBLEM
2. PROPOSE SOLUTIONS
3. FIND THE MOST APPROPRIATE SOLUTION
ETHICAL
SCIENTIFIC
LEGAL
AESTHETIC
ECONOMIC
EMOTIONAL
POLITICAL
what's going on?
impact?
good bad
how pressing?
solutions
solutions
solutions
impact?
good bad
can it be put into effect?
YES? NO?
is it in time?

Discuss and define the seven words in the outer ring.
Why do you think each component is important in STS problem solving?
An outline of the three steps in the problem solving process is presented below:

I. Define the Problem:

- A. What is happening?
- B. What are the component parts?
- C. What are the familiar patterns?
- D. What is the impact?
- E. How important is the problem?

II. Propose Solutions:

III.Decide on the "Most Appropriate" Solution

A. Consider potential impacts
B. Consider workability
C. Consider timeliness

IV. Argue Your Case

A. Keep an open mind
B. Remain rational

STS Assignment #2

Using the above model, identify and discuss ideas and solutions to any problem related to "fish finding". Present your argument in the form of a written paper. The supplement on "Fishing with Sonar" may be of help in organizing your thoughts.

Fishing with Sonar

The same technology th
being used to protect a

During World War II, sonar, which was intended for use in locating enemy submarines, sometimes found fish instead of U-boats. Large fish or schools of fish would interfere with the sonar signals and cause alarms to sound and escort ships to swing into action.

After the war, engineers sought to capitalize on sonar's capacity to locate fish. The result was the development of sophisticated echo-sounding devices that can not only pinpoint the location of the fish but can also differentiate among kinds of fish, their numbers and even their size. The latest echo-sounders can even distinguish between different schools of fish swimming in layers, one above the other.

With this technology, fishermen no longer rely solely on their years of experience to find schools of fish. Sonar helps them decide where and how deep to drop their trawls. It also gives them a rough idea of how many fish they are likely to find at a given location.

But where the new technology has solved one set of problems, it has created another: The danger now is that fishermen might misuse this new information and fish a stock too low—that is, harvest so many fish that the species itself is threatened. It almost happened once. After World War II, the increased efficiency of the North Atlantic fishing fleet depleted the herring stock until it was dangerously low. The fishermen from all the North Atlantic countries agreed to stop fishing for herring until the stock increased.

NET RESULT: Modern fish-finding techniques, using sonar-type devices that track fish by echo location, have taken a lot of the uncertainty out of catches like this one. The devices have proven so successful for Norwegian fishermen that they have had to set quotas to avoid depleting the stock of fish on which their livelihoods depend.

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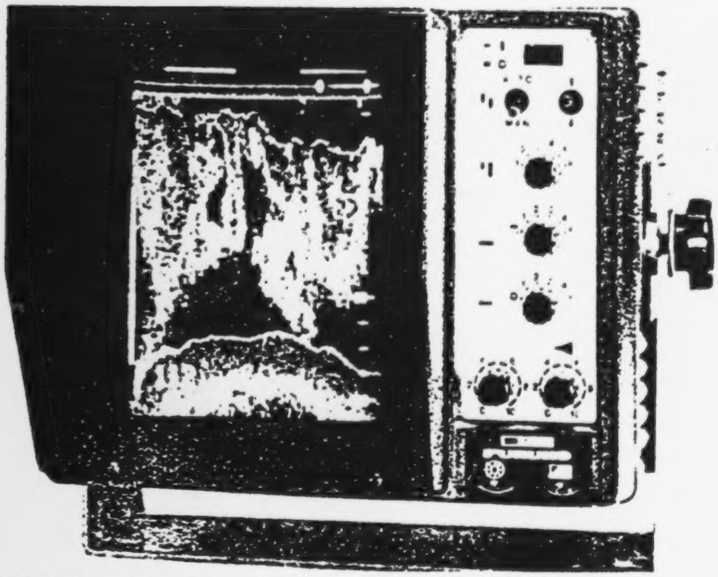


ECHO, ECHO: New echo locators, such as this color video sounder, are now used not only to find where the fish are in the ocean's depths, but how dense the schools are, and even what varieties of fish are to be found.

Setting Limits on Success

To prevent this type of catastrophe from occurring in the future, experts such as Gudmund Vestnes of the Marine Research Institute of Bergen, Norway have developed an information-gathering network for the fishing industry. They use the same equipment that helps *catch* the fish to collect information that protects against too many fish *being caught*. "We collaborate with research vessels from all the North Sea countries," he says, "as well as those from Great Britain, the Soviet Union and others." That information enables the Institute to calculate how much of each species should be harvested each season. "The tonnage of fish is calculated," Vestnes says, "and this is given to the political authority, which divides the fish stocks among the countries. The amount we advise the fishing authority to take out is divided among the fishermen," so each vessel gets its quota.

Control over the individual boats is precise. "They can't go out before they are given a quota for the kind of fish they are permitted to catch," Vestnes states.

Year after year, season after season, the fishing boats go out as they have for centuries. The work is still hard and dangerous: the winter gales are of blood-chilling ferocity. The information that is available now means a better chance of success on every voyage: and when information is wisely used to manage the harvest, the fish get an even break, too. ■

Further Readings

Dunlap, G.D. *Navigating and Finding Fish with Electronics*. Camden, Maine: International Maine Publishing Company, 1974.

Straightforward and sophisticated description of how electronic devices are used to find fish. Lots of photos and illustrations; only 80 pages. This book is recommended to the student or teacher who is specifically interested in how electronic fish finding works.

Time-Life Books, Eds. *Navigation*. New York: Time-Life Books, 1975.

A clearly written and well-illustrated introduction to coastal and inland water navigation. Chart and map reading, navigational aids such as lighthouses and buoys, radio navigation and sonar fish finding are all covered here. Simple description of the use of sonar for navigation and fish finding.

von Brandt, Andres. *Fish Catching Methods of the World*. London: Fishing News (Books), 1972.

Detailed but very interesting survey of fishing methods around the world. Lots of photos and drawings; covers fishing from Canada to China, Italy to Thailand, Africa to California. Thorough and fascinating for any student (or teacher) who is interested in all the different ways fish are tracked and caught around the world. (110 Fleet Street, London, EC4, England).

Warner, William W. *Distant Water*. Boston MA: Little, Brown and Company, 1983.

Fascinating and well-written account of the North Atlantic fishing industry, told from the point of view of the author, who spent months on the North Atlantic fishing vessels of five different nations. Warner discusses the effect of increased technological efficiency on fishing stocks, and, in the appendix, illustrates the different types of trawl nets and sonar fish finders currently in use.

How SONAR Works

SONAR is an acronym for *so*und *na*vigation *ra*nging. It is used to locate objects underwater or to aid communication between submarines or between a submarine and a surface vessel. The sonar or echo-sounding device consists primarily of a *transducer*, which converts electric energy to acoustic energy and back again to electric energy, in much the same way as a telephone receiver works. The transducer is in direct contact with the water, usually suspended from the hull of a surface vessel.

Once sound waves have been "projected" into the water through the transducer, the transducer then functions as a hydrophone and "listens" for the return signal or echo of the sound waves as they bounce back from the ocean floor or from any other object that might lie in their path.

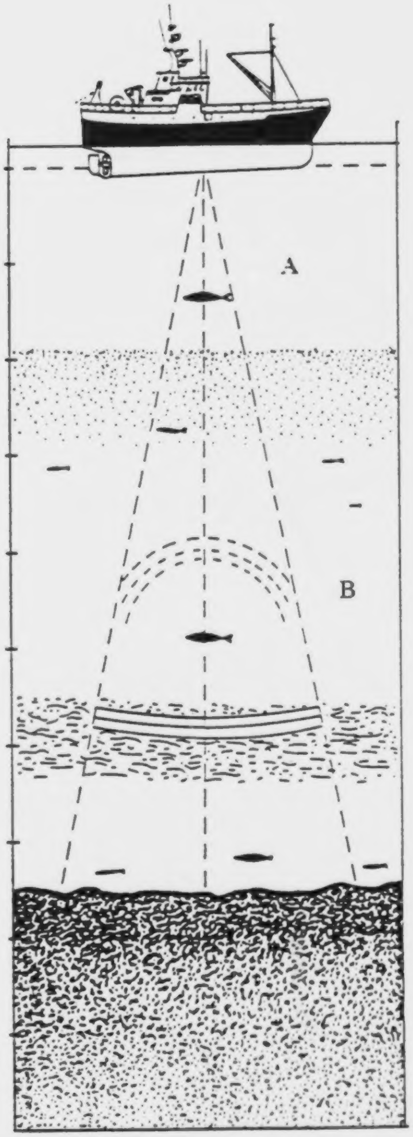
The transducer then converts this returning echo back to electric energy which may be analyzed to determine the range, bearing and nature of the object intercepted. The great advances in echo-locating technology in the last four decades have been in reading these signals to get even more and better information.

The Comings and Goings of Sound

While fishermen think about fishing, the sonar equipment they use makes calculations. Based on the speed of sound in water, the equipment can calculate how far away the fish are according to the length of time it takes for the reflected sound to return to the ship.

Sound travels at different speeds in different materials, depending on how well the material conducts it. In fact, sound travels faster through most other substances than through air. The speed of sound in water, for instance, is roughly five times the speed of sound in air.

The speed of sound in a material will, in general, depend on the temperature and the pressure and on impurities in the material (salt in water or humidity in air, for example), as well as on the material itself.



In the drawing, fish (A) and fish (B) have the same reflective properties. Between them are a thin layer of plankton and several fish of varying sizes. As the sound pulse from the echo locator travels down through the water, the wavefront area increases in proportion to the square of the distance from the transducer, and the intensity of the sound is correspondingly reduced. Although fish (A) and fish (B) are at different depths, the receiver compensates for the loss of signal strength and makes both echoes appear to be equal—alerting the fishermen that the two fish are the same size.

Sample STS Curriculum (Component 4.2)

The lessons contained in this section are intended as a sample of activities that illustrate the integration of science, technology, and society. For a sample complete STS curriculum, see Decisions for Today and Tomorrow (Iozzi & Bastardo, 1987).

Living Conditions

Materials:

Yarn, ruler's cards, 6 large sheets of paper, three bread slices, bread knife, data sheets, scissors, Hershey's chocolate kisses.

Readiness:

Begin the activity by discussing the following questions:

1. Where would you prefer to live? Why?
2. What does the term "quality of life" mean?
3. What does science and technology have to do with quality of life?
4. How have science and technology influence mortality and longevity?
5. What influence does population growth have on:
    a. natural resources
    b. pollution of air and water
    c. biodiversity (endangered species, deforestation)
    d. soil depletion and fertility
    e. greenhouse effect and ozone layer
6. Do all societies use food and natural resources the same way? Explain.

Procedure:

1. Start the activity by placing large sheets of paper on the board. Have students draw an outline of Asia, Africa, Europe, USSR, North America, and South America on the sheets. Aim to have the outlines proportional in size. Use references if needed.
2. Then place the outlines on the floor to represent a world picture. Arrange the yarn for the six world regions (see attached sheet for sizes) around the drawings.
3. Cut the bread into twelve equal-sized sections.
4. Count the number of participants.
5. Apportion students to land areas as on attached sheet. Have students stand within the assigned area.

Note: Numbers are based on 50 students; adjust accordingly. Begin this part of the activity by assigning a ruler for each area. Then fill in the rest of the people.

6. Have rulers share some statistics, such as:
   - a. current population
   - b. birth rate
   - c. death rate
   - d. annual growth rate
   - e. doubling time
   - f. infant mortality rate
7. Discuss the above.
8. Indicate that the loaf of bread represents the world's protein consumption per day.
Distribute it as follows:

1/12 to North America
1/12 to Latin America
1/12 to USSP
1/12 to Africa
2/12 to Europe
6/12 to Asia

Have the rulers distribute the bread. Discuss the implications.

"FOOD FOR THOUGHT"
AMBASSADORS' CARDS

THE AFRICA AMBASSADOR - green

I am the African Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 601 million.
B. Our birth rate is 44 per 1000.
C. Our death rate is 16 per 1000.
D. Our population's annual growth rate is 2.8%.
E. At this rate we will double our population in 24 years.
F. By the year 2000 we are projected to have 880 million people.
G. Our infant mortality rate is 113 per 1000.
H. Our life expectancy at birth is 51 years.
I. Our women bear an average of 6.3 children during their lifetimes.

THE NORTH AMERICAN AMBASSADOR - blue

I am the North American Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 270 million.
B. Our birth rate is 15 per 1000.
C. Our death rate is 9 per 1000.
D. Our population's annual growth rate is 0.7%.
E. At this rate we will double our population in 101 years.
F. By the year 200 we are projected to have 296 million people.
G. Our infant mortality rate is 10 per 1000.
H. Our life expectancy at birth is 75 years.
I. Our women bear an average of 1.8 children during their lifetimes.

THE ASIAN AMBASSADOR - red

I am the Asian Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 2 billion, 930 million.
B. Our birth rate is 28 per 1000.
C. Our death rate is 10 per 1000.
D. Our population's annual growth rate is 1.9%.
E. At this rate we will double our population in 37 years.
F. By the year 2000 we are projected to have 3 billion, 598 million people.
G. Our infant mortality rate is 86 per 1000.
H. Our life expectancy at birth is 61 years.
I. Our women bear an average of 3.7 children during their lifetimes.

THE LATIN AMERICAN AMBASSADOR - yellow

I am the Latin American Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 421 million.
B. Our birth rate is 30 per 1000.
C. Our death rate is 8 per 1000.
D. Our population's annual growth rate is 2.2%.
E. At this rate we will double our population in 31 years.
F. By the year 2000 we are projected to have 537 million people.
G. Our infant mortality rate is 58 per 1000.
H. Our life expectancy at birth is 66 years.
I. Our women bear an average of 3.7 children during their lifetimes.

THE EUROPEAN AMBASSADOR - white

I am the European Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 495 million.
B. Our birth rate is 13 per 1000.
C. Our death rate is 10 per 1000.
D. Our population's annual growth rate is 0.3%.
E. At this rate we will double our population in 272 years.
F. By the year 2000 we are projected to have 507 million people.
G. Our infant mortality rate is 13 per 1000.
H. Our life expectancy at birth is 74 years.
I. Our women bear an average of 1.8 children during their lifetimes.

THE SOVIETY AMBASSADOR - pink

I am the Soviet Ambassador. Here are some of the statistics that shape my region of the world:

A. Our population is estimated at 284 million.
B. Our birth rate is 19 per 1000.
C. Our death rate is 11 per 1000.
D. Our population's annual growth rate is 0.9%.
E. At this rate we will double our population in 79 years.
F. By the year 2000 we are projected to have 312 million people.
G. Our infant mortality rate is 26 per 1000.
H. Our life expectancy at birth is 69 years.
I. Our women bear an average of 2.5 children during their lifetimes.

"Food for Thought" - 1987 Update

REGIONAL INFORMATION CHART
(BASED ON 50 PARTICIPANTS)

	North America	Latin America	Europe	USSR	Asia	Africa
Yarn	36 ft.	35 ft.	18 ft.	36.6 ft.	40 ft.	42 ft.
Population	3	4	5	3	29	6
Percent of World's Land Area	16%	15%	4%	16.5%	20%	22%
Percent of World's Population	5%	8%	10%	6%	58%	12%
Urban Population	3/4	2/3	3/4	2/3	1/3	1/3
Arable Land	1/5	1/3	1/2	1/5	2/5	1/3
Peanuts Ideal World Real World	 3/person 3/person	 3/person 2/person	 3/person 3/person	 3/person 3/person	 3/person 2/person	 3/person 2/person
Bread	1/12 loaf	1/12 loaf	2/12 loaf	1/12 loaf	6/12 loaf	1/12 loaf
Per Capita GNP (1985)	$16,150	$1,700	$7,280	$7,400	$970	$710
No. of Kisses	81	9	36	37	5	4
1983 Per Cap Consumption of Energy Gigajoules Matchbooks	 274 55	 32 6	 122 24	 173 35	 18 4	 12 2

NOTE: To conduct this simulation with 25 participants, double over the yarn (or use half as much) and distribute the population as follows: 1 in North America, 2 in Latin America, 3 in Europe, 1 in the USSR, 15 in Asia, and 3 in Africa.

Four Hands On the Clay

Purpose: To enhance an atmosphere of cooperation and trust.

Materials:

Block of clay for each two participants
Clay needs to be pliable and a fairly large chunk.

Procedure:

Introduce the activity by saying: "In this exercise, you work in pairs with a partner, but you do it with your eyes closed, and with no talking, and you will not know who your partner is. The task is for the two partners to make something from the clay."

The clay blocks should be distributed around the tables so that partners can sit opposite each other with the clay between them. If possible, the pairs should not be too close together.

The pupils are then asked to remove watches, bracelets, and rings and to roll up their sleeves. The pupils are then lined up along one or two walls and the following instructions are given:

"Please close your eyes and try to keep them closed throughout the exercise. Also, from now on, there's to be no talking, laughing, or making of any noise which would allow others to identify who you are. Once everyone is quiet and with eyes closed, I'll begin leading you, one-by-one, over to the chairs by the clay. When I've put two partners oppose each other, I'll place their four hands on the clay, and they should begin making something together. Does everyone understand? Okay. Eyes closed, no sounds."

There are various approaches to arranging the pairs. Since the pupils almost always ask the teacher how she/he chooses pairs, it's good to decide this before beginning. Some teachers like to arrange the pairs for what they feel will give interesting results.

When finished, each pair should signal completion by tapping each other's hand four times, opening the eyes, and sitting quietly until all are finished.

Discussion:

A broad question such as, "What was it like?" will get the class talking about what happened. This can be followed with more specific questions directed towards those describing their experiences. With the first few pupils the teacher will probably need to ask the questions. Then this responsibility should be turned over to the class as a whole. These questions can focus on three aspects of the exercise: decision processes, communication, and feelings.

1. Decision Processes: How was the decision reached about what to make; was it a joint decision; did it develop from interaction with the partner, or was a choice made already while waiting to be seated; what determined the choice, etc.?

2. Communication: What were the kinds of communication that took place between partners; were there times when you were trying to say something, but other times when the communication "just happened"; did communication every really stop; wasn't doing anything, stopping work, a good form of communicating; were feelings being communicated between partners; how, etc.?

3. Feelings, Emotions: Starting right from the time the pupils listened to the instructions, have them think about their feelings during the decision period about what to make, during the making, when things were going well, and/or badly, their frustrations (or pleasures) from not talking and seeing, their reactions to an unknown partner, any of this which they want to share with the class should be encouraged. Feelings are always harder to talk about, but this exercise is different enough from usual situations, far enough removed from "reality" that many pupils find it easier looking at their emotional reactions and sharing them openly.

Another interesting aspect of the exercise is the effect of working with an unknown partner. Were many guessing about their partner? What would be the difference if they knew? Was it important to know if the partner was a boy or girl? Do we play different roles with boys and girls and with people we don't know--strangers?

After covering the events of the exercise itself, the discussion should be continued by picking up one or more of the three aspects and developing and applying the concepts to real-life situations.

Application:

This activity can be related to real-life situations. Contrary to this experiment, in many real-life situations, we have some control over the amount of information that we apply to the decision process. Since the topic of using information, applying knowledge for decisions, is important throughout this approach and arises in all the units, only one project will be described here. This is a study that can be done with other pupils, teachers, headmaster, family members, city officials, etc. In each case, have the person think about a recent important decision. They are then to reconstruct the basis for their decision, the information which they used, and how they valued it, how much confidence they had in the various kinds of information, etc. They could then describe whether the total amount of information was enough or whether they wished they had more. Also, how did they feel when they first made the decision and how do they now feel about it. Do they now wish they had done it differently? This kind of study can easily be designed and carried out by the pupils.

Multidisciplinary Aspects:

Arts: Some pupils feel they are not able to make clay sculptures. They are too afraid of failure to even try. However, doing this exercise, with eyes closed, seems to "take the pressure off", and they are then pleasantly surprised by what they've made and the fun they've had. If this kind of reaction does come up in the discussion, it could be generalized into the kinds of things which do inhibit self-expression; for example, standards of judgment, feelings of inadequacy, and the idea of talent as something only special people have. It is also interesting to look at the choice and appearance of the clay objects made by the pairs and see if it reflects some of the differences in relationships between the pairs. For example, can one see from the final result that the bowl Jo and Bo made expresses their conflicts while you just know Kim and Karen had fun together making their family of bears. This can initiate a discussion of the general relationships between the way a person feels, thinks, and reacts (his/her personality) and the pictures, sculptor, music she/he makes. Is it himself/herself that the artist is trying to communicate? How much does an artistic work communicate? Were the pupils surprised at the amount of communication between them during the exercise? Does our overemphasis on spoken communication blink us to all the other kinds of messages we are continually getting and giving?

Social Studies: This exercise is usefully applied to the topic of family relationships and, for the older pupils, dating and marriage. The varying range of experiences the different pairs have presents good immediate contact with some of the pleasures of cooperation under difficult conditions as well as the frustrations and aggressions of conflict. The situation of this exercise, where two people are joined by a task that can be done in many ways, is similar to a couple bringing up their child.

Now Isn't That a Grabber

Purpose: To enhance sensory perception in a variety of social contexts.

Procedure:

The class divides into pairs; one is "blind", with eyes closed or well covered, and the other is his/her leader. The pairs are instructed to walk around for about 10 minutes; depending on circumstances, this can be inside and/or outside. Doing both is better because of the greater variety of experiences possible. The instructions must include: (1) no one is to talk during the whole exercise, and (2) the leader should not turn the walk into an obstacle course for the blind pupil. Sometimes there is a tendency to "tease". Rather, most of the walking should be fairly easy and the leader should try, instead, to be creative in finding a variety of experiences for the blind pupil such as trying to identify objects by touch, being left alone for a few minutes, running (on smooth ground) and being exposed to a variety of sounds. The teacher can mention these possibilities specifically, but it is better to just ask the pupils to use their own imagination for creating a variety of experiences.

After about 10 minutes, the pairs switch roles and continue their walk for another 10 minutes. The teacher can ask for this switch to take place in the classroom or let the pairs decide.

Variation:

The pairs don't know who their partner is. Half the class covers or shuts their eyes. The other half are the leaders and pick their partners from the blind group without any talking. After the 10-minute tour, all pairs return to the classroom and the selection process is then repeated with the leaders being the blind group. In all other respects, the procedure and instructions are the same as above.

Discussion:

Concepts:

1. Infants are more trusting than adults.
2. Dependency - what are our reactions to being dependent?
3. Communication of emotions through bodily posture, movement, and tension.
4. Role of past experiences in trust-mistrust.
5. Unfamiliarity and mistrust.. .increasing mistrust of those more unlike oneself, e.g., opposite sex, social class, racial and cultural differences.
6. Earn trust, earn power.
7. Sensitivity to the environment; how did one's awareness of the environment change with loss of sight?

Application:

Relate the discussion items to our own social system and the ways social systems handle trust and responsibility (time cards, perscriptions, teacher cert).

What are the functions of rules in society?
What are the functions of rules in science?

Extensions:

1. Family: Pupils do a study of changing (or unchanging) family patterns related to trust and mistrust. They compare their "rules" with those their parents and grandparents had as children. Additional data sources: autobiographies, novels, books for parents on raising children. This could be followed up with a parent-pupil evening meeting which began with a trust walk and then, in the discussion, ended up with experiences and feelings about family and school rules as they relate to responsibility and trust. A meeting of this kind is useful in introducing parents to the ideas of the curriculum approach.

2. School: Similar to 1., except that the subject is the school.

3. Senses: Repeat the blind trust walk but for the purpose of exploring the human senses. Before beginning, the pupils are instructed to concentrate on their other senses and they may try to see if they can tell when they are approaching a wall. Most will experience sounds as extremely loud and this is an example of how our brain's system for selective attention involves inhibition of sensory input. Some pupils may want to try a trust walk without vision and hearing. About the only practical way to eliminate hearing is to have the pupil carry a small transistor radio with an earphone in place and the volume (of music) turned up high.

4. Lending Money: Design and do an experiment on interpersonal trust. For example, see if strangers will lend money with a promise of mailing it back the next day. What difference is there if the pupil needing the money is a boy or girl, is neatly or sloppily dressed? Are old or young, males or females, more likely to lend money? Make hypotheses about the results before gathering the data, and then make a theory. There are many other kinds of interpersonal trust situations which can be studied experimentally.

5. Secrets: Can you trust fellow pupils (or teachers) to keep a secret? Design an experiment to examine some of the factors which influence this. For example, are girls more likely to keep secrets about other girls, but pass it on if it's about a boy? Is the same thing true between racial, religious, ethnic, and social class groups? Why?

6. International Mistrust: Spying. There are commonly accepted diplomatic procedures for handling exposed spies of another country. As the Stalin purges of the 30's and the Watergate affair demonstrate, spying also takes place within a country. The mass media are filled with spy stories, both factual and fiction. A project on this could examine some of the political, psychological, and moral aspects of spying.

7. The United Nations system and other international institutions (e.g., International Court of Justice) can be examined as ways of handling trust and mistrust amongst nations.

8. Managing conflict where there is little or no trust: black-white in USA, Catholic-Protestant in North Ireland, Arab-Israeli. Do a "case study" comparing conflict management situations with and without a loss of trust. Refer back to the pupil's own emotional reactions during the trust walk for an understanding of the emotional component.

Multidisciplinary Aspects:

Language: The trust walk itself has been successfully used as a means of giving pupils a shared experience to initiate an active conservation in a foreign language. One can also compare languages by listing all the words and expressions concerned with trust and mistrust. Does such a comparision say something about differences in national character? (Partial list from English: Confidence, faith, suspicious, wary, liar, reliance, support, uphold, responsible, doubtful, gossip, believable, team spirit, solid citizen, teacher's pet, tattletale, stool pigeon, con man, informer, speak with a forked tongue)

History: Projects like 1, 2, 6, 7, and 8 are relevant to history courses. A historian has labelled the 20th Centry, "The Age of Anxiety." Does mistrust cause anxiety?

Geography and Environmental Studies: Do a comparison of aspects of trust-mistrust; responsibility the different kinds of man-environment conditions; e.g., Eskimoes, isolated mountain villages, repetitive natural disaster areas, urbanized regions, small islands, etc. How do our feelings change in different man-made and natural environments, e.g., tiny and huge rooms, candle and fluorescent light, top of a mountain and deep in a valley? Are the different kinds of dwellings people live in an indication of their trust in others?

Biology: Is trust necessary for cooperation? Look at cooperation-competition, the hunter and the hunted, in different animal species. Is fear and mistrust an instinct or is it learned, or both? What is the physiology of the emotions the pupils felt on their blind trust walk? Project 3, emphasizing sensory reactions and the selective attention and inhibition process, is especially relevant to biology. How do the sensory worlds of different animals compare? We know little scientifically about the pleasures of sensation, but it's an interesting and important topic for biology and moral education.

Literature: The trust walk is a useful beginning to some of the extensive literature in which trust-mistrust are the basic theme. It may also be related to stories of the blind or deaf. Pupils may also use it as a theme for writing stories or poems or act plays-autobiographical and fictional.

Arts: Paintings, sculpture, and music often illustrate aspects of trust and mistrust, e.g., mother and child, Edvard Munch's paintings of women, songs, and operas about "love betrayed".

High Tech Sprouting

Concepts: Recycling, Regenerative Environmental Education, and Technology As a Process.

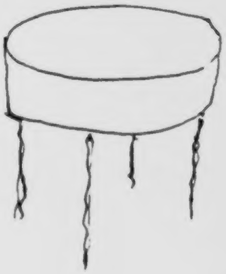
Materials:

3 2-litre plastic pop bottles
2 pans hot water
Camp stove/fuel
Blender
Plant cutters
Plotting soil
Cotton string
Willow tree twigs or stems
Scissors
Serrated-edge knives
Plant cuttings (geraniums work well)
Wooly socks
Paper towels
Water supply

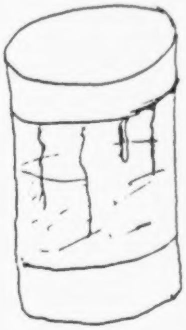
This activity involves recycling plastic pop bottles (high tech-throw away culture), regenerative environmental education (healing and reviewing powers of nature), and technology (cooperative assembly, both process and product).

Task Outline:

1. Remove bottom from 1 2-litre plastic pop bottle by dipping in boiling water and then pulling off the bottom.
2. Cut the tops off of 3 2-litre plastic pop bottles (2 with bottoms, 1 without bottom). Use a serrated knife with one person holding the bottle and the other person cutting and holding the neck of the bottle. Make the cut below the point where the bottle no longer gets larger. Place the bottle on a solid surface. BE CAREFUL!!
3. Cut cotton string into pieces about 30 cm long.
4. Thread the cotton strings through the holes in the free bottle bottom so that at least one end hangs down from each hole.



5. Fill each bottom with potting soil.
6. Cut enough willow twigs into 4 cm long pieces to fill your cupped hands.
7. Place the twigs in a blender with about 750 ml of water. Blend for 30 seconds.
8. Pour the entire contents into one of the bottles with a base.
9. Place the bottle bottom filled with the soil on the top of the bottle with the willow mixture.



10. Moisten the soil slightly.
11. Insert the plant cutting with buds or leaves pointing up. Wait for growth.
12. Plant the rooted tree out either early in the spring or early in the fall.

Division of Labor

Task	# of Persons
1. Bottom removers	2
2. Bottle cutters	4
3. String cutters and threaders	4
4. Soil fillers	2
5. Willow cutters	6
6. Willow blenders	2
7. Assemblers	3
8. Cutting sticker inners	1
9. Government inspectors	all others

Extension:

1. Put an old wooly sock over your shoe. Walk through a variety of habitats. Remove the sock and place it in a sprouting bottle.

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Chapter 6
STATE CORE CURRICULUM

The State Core (Component 5.1)

Utah has a mandated elementary science core curriculum. Since most Utah State University graduates of the SODIA program teach in Utah, it is important that they be familiar with the core.

The core consists of specified standards and objectives for all grade levels. District and teachers may elect to achieve the objectives in a variety of ways. The section that follows lists the standards for the entire K-6 elementary Core Curriculum (USBE, 1986). Objectives are omitted to save space. Each standard has a number of sub-objectives.

SCIENCE LEVEL K

SIS NUMBER: 3000
SIS CODE: SI

Course Description, (Levels K-3)

The students' learning experiences in Levels K-3 are derived from their interests and investigations of the environment. Real or contrived, the environment must be one that interests them and one in which they are active participants. Learning experiences are equally drawn from the areas of life science, physical science, and earth science. Students using their five senses, investigate some observable and inferential characteristics and phenomena of plants and animals, matter and energy, earth and space, natural resources, ecology, weather, and seasons. The students' learning activities in each of the levels should be centered around concrete experiences. By the end of Level 3, most of the students should be able to demonstrate the ability to use the basic process skills of observing, classifying, inferring, recognizing and controlling variables, predicting and interpreting data, and experimenting and communicating.

Core Standards of the Course

Standard 3000-01 **The students will use the five senses to gather and compare information about their natural environment.**

Objectives

3000-0101. Determine the shape, size, and texture of a common object: e.g., ruler rectangle; nesting blocks—large, small; sandpaper—rough; cotton—soft.

3000-0102. Compare the color, shape, size, texture, and location of common objects: e.g., tooth—white; peak of house—triangle; tree— large; leaf—smooth; mountain—far.

3000-0103. Identify and distinguish some common sweet, sour, salty, and bitter foods: e.g., marshmellow—sweet; lemon—sour; pretzel— salty; bitter chocolate or whole cloves—bitter.

3000-0104. Recognize some common scents and odors, e.g., pine needles, perfume, cinnamon stick, onion.

3000-0105. Students will identify sounds and sources of sounds, e.g., telephone, whistle, vacuum.

3000-0106. Infer which sense or senses are used to make an observation: .e.g, fingers—touch; eyes—sight; nose—smell; tongue—taste; ears—hear.

Standard 3000-02 **The students will categorize animals according to similarities and differences.**

Objectives

3000-0201. Conclude that there are many different kinds of animals.

3000-0202. Compare how animals differ in size, shape, and color.
3000-0203. Group animals as domestic and wild animals.
3000-0204. Recognize different body coverings of animals, e.g., fur, shell, feathers, hair.
3000-0205. Show how animals move: e.g., snails—crawl; seagulls—fly; kangaroos—jump.
3000-0206. Distinguish likenesses and differences between young animals and their parents.

Standard 3000-03 **The students will observe and describe variations in plants.**

Objectives
3000-0301. Recognize different kinds of plants, e.g., grass, bushes, flowers, trees.
3000-0302. Observe that different plants grow at different rates.
3000-0303. Show that some plants have seeds and discover that seeds differ in size, shape, and color.
3000-0304. Discover that a seed is a living thing and can grow into a plant.
3000-0305. Demonstrate the plants have many parts; some parts grow above the ground and some underground.

Standard 3000-04 **The students will use magnets and identify objects that are affected by magnets.**

Objectives
3000-0401. Use magnets and describe what they look and feel like.
3000-0402. Find objects that are attracted by a magnet and objects that are not.

Standard 3000-05 **The students will observe and describe some basic components of weather.**

Objectives
3000-0501. Compare the characteristics of sunny days, rainy days, cloudy days, windy days, snowy days, and foggy days, or a combination of these.
3000-0502. Recognize that clouds affect the weather and have different shapes.
3000-0503. Discover that the sun warms the earth, air, and objects and helps determine the weather.
3000-0504. Demonstrate that wind is moving air.

Standard 3000-06 **The students will describe and compare seasonal changes in plants, animals, and people.**

Objectives
3000-0601. Identify some characteristics of each season.

3000-0602. Investigate how trees and other plants look during the different seasons.

3000-0603. Compare and contrast the habits and activities of animals and people during the different seasons.

SCIENCE LEVEL I

SIS NUMBER: 3010
SIS CODE: SI

Core Standards of the Course

Standard 3010-01 **The students will use their five senses to perceive and organize objects and events.**

Objectives

3010-0101. Classify (group) objects by size, color, and shape.
3010-0102. Put in order a collection of at least three like objects according to size or weight, e.g., shortest to tallest, lightest to heaviest.
3010-0103. Identify the sources of different sounds, odors, tastes, and light.
3010-0104. Compare and describe different kinds of texture.
3010-0105. Identify the eyes, ears, nose, tongue, and skin as parts of the body that can detect particular sensations.

Standard 3010-02 **The students will group animals according to their physical characteristics and identify the basic needs of animals.**

Objectives

3010-0201. Investigate a variety of animals and discuss some likenesses and differences among them.
3010-0202. Group animals as those that hatch and those that are born alive.
3010-0203. Identify and name some common animals; describe the places where they live and why they live there.
3010-0204. Infer that all animals need food, air, water, and shelter.
3010-0205. Recognize that animals need proper care and handling.

Standard 3010-03 **The students will describe and group plants and seeds; categorize plant parts; identify plants as living organisms; and experiment with seeds.**

Objectives

3010-0301. Describe similarities and differences in plants and seeds.
3010-0302. Discover that seeds and plants differ in size, color, shape, texture, and outer covering.
3010-0303. Identify seeds, leaves, roots, stems, and flowers as being common to most plants.
3010-0304. Find out what is inside a seed, e.g., peanut or bean shows example of leaf and root; and determine conditions needed for seeds to sprout, e.g., warmth, moisture, air.
3010-0305. Investigate variations in the ways that plants produce and disperse seeds.

3010-0306. Recognize that seeds develop into the same kind of plant that the seed came from and both are living organisms.

Standard 3010-04 **The students will compare the three states of matter and cite examples of matter changing from one state to another.**

Objectives

3010-0401. Identify materials in the environment as solids, liquids, and gases.
3010-0402. Describe similarities and differences among the three states of matter.
3010-0403. Observe that the state of matter can be changed, e.g., water to ice, shortening to oil, clouds to rain, sugar to syrup, candle to wax.
3010-0404. Investigate what happens over several hours to water in a sponge, towel, or shallow pan.

Standard 3010-05 **The students will identify characteristics of water and its uses.**

Objectives

3010-0501. Investigate water as a solid (ice), liquid, and gas (water vapor).
3010-0502. Demonstrate that some common materials dissolve in water and some do not.
3010-0503. Discover some common objects that float in water and some that sink in water.
3010-0504. Describe ways that people have fun with water.
3010-0505. Discuss that water is a limited resource and should not be wasted.

Standard 3010-06 **The students will identify characteristics of air and its uses.**

Objectives

3010-0601. Observe air directly with the sense of touch and indirectly with the senses of sight, hearing, and smell.
3010-0602. Conclude that air is all around them, has weight, and takes up space, e.g. inflated and deflated ball or balloon.
3010-0603. Discover that air can make objects move.
3010-0604. Identify ways that people use air and the problems of air pollution.
3010-0605. Infer that all plants and animals need air to stay alive.

Standard 3010-07 **The students will identify sources of energy and describe ways to conserve energy.**

Objectives

3010-0701. Observe the wind as a source of energy, e.g., sailboats, windmills.
3010-0702. Describe ways that coal and wood are sources of energy, e.g., fireplaces, furnaces, campfires.
3010-0703. Recognize gasoline as a source of energy, e.g., cars, trucks, lawnmowers.

3010-0704. Discuss food as a source of energy, e.g., hamburgers for people, hay for cows.
3010-0705. Identify the sun and water as sources of energy, e.g., heat, light, electricity.
3010-0706. Describe ways to conserve energy, e.g., turning off lights, televisions, and radios not in use; closing doors in heated and air conditioned buildings; recycling aluminum cans.

Standard 3010-08 **The students will describe and record weather related information and suggest appropriate activities for different kinds of weather.**

Objectives
3010-0801. Describe different kinds of weather.
3010-0802. Observe, describe, and record the weather on a given day(s).
3010-0803. Distinguish between two very different temperatures with and without the aid of a thermometer.
3010-0804. Describe appropriate activities and clothing for different kinds of weather.

Standard 3010-09 **The students will identify time categories, name and sequence the four seasons, and describe seasonal changes.**

Objectives
3010-0901. Classify what they might do according to time categories such as morning, noon, or night, day of the week, or season of the year.
3010-0902. Name each season and identify its typical characteristics.
3010-0903. Place in proper order the seasons of the year.
3010-0904. Observe and describe changes in the local seasons.
3010-0905. Conclude that seasons vary in temperature, length of day, and effect on plant and animal life.

SCIENCE LEVEL 2

SIS NUMBER: 3020
SIS CODE: SI

Core Standards of the Course

Standard 3020-01 **The students will discover that animals differ in different stages of their lives.**

Objectives

3020-0101. Describe some different kinds of animals and their young found in the student's environment.

3020-0102. Identify some baby animals and speculate as to what changes will take place as these animals grow.

3020-0103. Infer how animals care for their young.

3020-0104. Conclude that life is a cycle which includes birth, growth, and death; and that animals are capable of different activities at different stages in their life cycles.

Standard 3020-02 **The students will investigate cause-effect relationships between various lightsources and shadows.**

Objectives

3020-0201. Identify light sources, e.g., sun, light bulbs, fire, stars.

3020-0202. Show that when an object blocks the path of light, a shadow of the object is formed.

3020-0203. Change the size and shape of a shadow by moving the object that casts it.

3020-0204. Demonstrate the sun's position using an object and its shadow.

Standard 3020-03 **The students will demonstrate principles of sound production and transmission.**

Objectives

3020-0301. Demonstrate that sound is produced when materials vibrate, e.g., rubber band, guitar string, tuning fork, drum, tambourine.

3020-0302. Demonstrate that the faster an object vibrates, the higher the pitch of the soundproduced.

3020-0303. Observe that sound requires something to carry it from one place to another, e.g., simple string-cup phone, and describe their observations.

Standard 3020-04 **The students will demonstrate and describe some properties and uses of magnets.**

Objectives

3020-0401. Discover, by experimenting, that magnets vary in strength and which objects are attracted to magnets.

3020-0402. Locate the north and south poles on a magnet and demonstrate that the magnetic field is strongest at the poles.

3020-0403. Identify some materials through which magnetism will pass.

3020-0404. Create a "picture" of a magnetic field, e.g., place a piece of paper over a magnet and sprinkle iron filings on the paper.

3020-0405. List some uses of magnets.

Standard 3020-05 **The students will investigate and measure some observable properties of heat.**

Objectives

3020-0501. Demonstrate that objects in the sunlight are warmer than the same objects placed in the shade.

3020-0502. Show that heat causes some things to melt.

3020-0503. Explain that the redline goes up or down becaue the liquid in the thermometer expands or contracts.

3020-0504. Determine the temperature of objects such as liquids, air, and solids (ice) by using a thermometer.

Standard 3020-06 **The students will classify rocks on the basis of observable charactertistics andidentify where rocks are used in their community.**

Objectives

3020-0601. Collect rocks and discover that they are found in many different places.

3020-0602. Identify rocks by observable characteristics: e.g., hard-soft, shiny-dull, smooth-rough, single color-multicolored.

3020-0603. Locate places in the community where rocks are used and describe how and where they are used.

3020-0604. Select rocks that have crystals in them and describe the crystals.

Standard 3020-07 **The students will identify properties, sources, and uses of water and label the basic stages of the water cycle.**

Objectives

3020-0701. Describe the importance of water in their daily lives.

3020-0702. Demonstrate that water can change from one state to another.

3020-0703. Discover that water evaporates and condenses.
3020-0704. Explain how water comes from the clouds in the form of rain, snow, sleet, and hail.
3020-0705. Label and discuss the basic stages of the water cycle.
3020-0706. Classify materials into two groups: those that absorb water and those that do not.
3020-0707. Evaluate the importance of reservoirs and irrigation practices.

Standard 3020-08 **The students will identify and describe the moon as a natural satellite, and compare natural satellites to man-made satellites.**

Objectives

3020-0801. Identify and describe the moon as a natural satellite of the earth.
3020-0802. Use a model to show that the moon is visible because it reflects light from the sun.
3020-0803. Conclude that it takes 24 hours for the earth to make one complete turn and four weeks for the moon to move around the earth once.
3020-0804. Infer why the moon looks bigger than the sun and the stars.
3020-0805. Compare man-made and natural satellites, e.g., launched, size, purpose.

SCIENCE LEVEL 3

SIS NUMBER: 3030
SIS CODE: SI

Core Standards of the Course

Standard 3030-01 **The students will compare different animal habitats and describe how animals behave in different ways to meet their life needs.**

Objectives

3030-0101. Compare an artificial habitat in a zoo, farm, home, or school with the natural habitat of an animal.

3030-0102. Compare several kinds of animals to see how their methods of gathering food and finding shelter are different.

3030-0103. Explain how environmenal factors (color, shading, cover) help an animal protect itself.

3030-0104. Recognize that some animals seem to have built-in "clocks" that tell them when to do certain things such as hibernate, migrate, or spawn. Investigate an animal that does each of these.

3030-0105. Differentiate between animals that are active during the day and those that are active during the night and discuss reason for the night-time activity of some animals.

3030-0106. Discover how plants and animals in an ecosystem interact with each other.

Standard 3030-02 **The students will grow and group plants and explain the effects of the environment on plants.**

Objectives

3030-0201. Observe and record on a graph the growth of a plant.

3030-0202. Compare and constrast the characteristics of the major plant groups, e.g., thosewith stems and those without.

3030-0203. Classify plants into sets and subsets of similar characteristics using leaves or flowers, e.g., group flowers by size and then color, or leaves by size and then shape.

3030-0204. Experiment with different parts of mature plants, e.g., roots, stems, leaves, flowers to determine which parts will grow into new plants.

3030-0205. Explain the effects of the environmental elements on plants, e.g., seasons, pollution, water, and the time of day.

3030-0206. Distinguish between evergreen and decidious plants.

Standard 3030-03 **The students will identify natural resources, how they are used, and how to conserve them.**

Objectives

3030-0301. Identify some commonly used natural resources, e.g., soil, water, wind, oil, trees.

3030-0302. Describe and demonstrate ways these natural resources are used.

3030-0303. Determine ways to conserve these natural resources.

Standard 3030-04 **The students will illustrate how matter can be categorized, weighed, and changed.**

Objectives

3030-0401. Identify matter as anything that occupies space and has weight.

3030-0402. Identify things that are not matter because they do not occupy space or have weight, e.g., heat, sound, light, electricity.

3030-0403. Observe that matter can be either a solid, a liquid, or a gas and can change from one state to another. Record observations.

Standard 3030-05 **The students will demonstrate how static electricity can be produced, investigate its properties, and describe lightning as an example of static electricity.**

Objectives

3030-0501. Demonstrate that static electricity can often be produced by rubbing two different kinds of material together.

3030-0502. Identify materials that are charged with static electricity by observing that they attract things, e.g., nylon and cotton threads, dry hair, small bits of paper.

3030-0503. Demonstrate that some charged objects attract each other and other charged objects repel each other.

3030-0504. Explain what causes lightning and thunder; discuss some safe and unsafe places to be when there is lightning.

Standard 3030-06 **The students will identify landforms and determine the relationship betweenthe earth's surface features and the forces that are constantly changing them.**

Objectives

3030-0601. Discover that the earth's surface has a variety of land forms, e.g., mountains, deserts, plains, lakes, rivers, oceans.

3030-0602. Compare the place where they live to a pictured area which may show mountains, deserts, plains, lakes, rivers, etc.

3030-0603. Identify factors that cause changes in landforms, e.g., erosion, weathering, volcanoes.

Standard 3030-07 **The students will demonstrate the earth's motions in space and describe events that occur regularly because of these motions.**

Objectives

3030-0701. Use a globe as a representation of the earth and locate the north and south poles.

3030-0702. Demonstrate how the earth and everything on it rotates and also revolves around the sun.

3030-0703. Use the measurements of time, e.g., hour, day, year and relate them to the earth's motion.

3030-0704. Discuss how the movements of the earth and moon cause the moon to appear in different shapes.

Standard 3030-08 **The students will be able to identify and describe simple machines, and give an example of each machine's use.**

Objectives

3030-0801. Identify a simple machine as a machine with few or no moving parts.

3030-0802. Describe a lever and demonstrate its uses, e.g., hammer, seesaw, can opener.

3030-0803. Describe an inclined plane and demonstrate its uses, e.g., wedge, ax, ramp, screw.

3030-0804. Describe and demonstrate a wheel and axle, e.g., pulley, egg beater, roller skates, bicycle.

SCIENCE LEVEL 4

SIS NUMBER: 3040
SIS CODE: SI

Core Description, (Levels 4-6)

In the core program in Levels 4-6, the students draw learning experiences each year equally from the areas of living things, matter and energy, and earth and the universe. Students become increasingly familiar with plants and animals, weather phenomena, satellites, household chemicals, changes in the earth's surface, the sun and the planets, forces, forms of energy, properties of matter, and other observable phenomena as they progress through these levels. The students' learning activities in each of the levels are centered around concrete (hands-on) experiences with real objects and events. By the end of Level 6, most of the students will combine the basic process skills to perform the integrated process skills of controlling variables, interpreting data, defining operationally, formulating hypotheses and models, and experimenting.

Core Standards of the Course

Standard 3040-01 **The students will identify characteristics of major groups of animals and classify them in different ways.**

Objectives

3040-0101. Classify animals as those with backbones (mammals, birds, fish, amphibians, reptiles) and those without backbones (insects, worms, shellfish).
3040-0102. Identify warm- and cold-blooded animals.
3040-0103. Classify carnivores, herbivores, and omnivores and recognize the char acteristics each group has for getting food, e.g., form of teeth, mouth parts, feet.

Standard 3040-02 **The students will identify several ecosystems and their components, describe plant and animal interactions in those ecosystems, and summarize some conservation practices.**

Objectives

3040-0201. Identify an ecosystem, e.g., grassland, forest, marshland.
3040-0202. Describe the relationship among the organisms in a simple food chain, and discuss the interdependence of plants and animals.
3040-0203. Infer how plants and animals in an ecosystem interact with each other.
3040-0204. Identify factors in the natural environment that can limit or change plant/animal populations.
3040-0205. Discuss some plant and animal conservation practices.

Standard 3040-03 **The students will produce different sounds, demonstrate what causes sound, how it travels, and identify problems created by noise.**

Objectives

3040-0301. Create sound using different objects.
3040-0302. Demonstrate that sound travels through solids, liquids, and gases.
3040-0303. Explain that sound travels in waves that spread out in all directions.
3040-0304. Discuss some problems sound creates in our environment and determine someways to prevent them.

Standard 3040-04 **The students will construct a simple circuit, identify conductors and insulators, and discuss how electricity is transmitted and used safely.**

Objectives

3040-0401. Using a dry cell (battery), wires, and a bulb, construct a simple circuit, causing the bulb to light.
3040-0402. Describe characteristics of a simple circuit. What happens when a circuit is closed and what happens when a circuit is open?
3040-0403. Determine by experimentation several items that are conductors and several that are insulators.
3040-0404. Distinguish between static electricity and current electricity.
3040-0405. Describe where electricity for our community comes from and how it gets to our homes.
3040-0406. Outline safe practices for the use of current electricity in and around the home.

Standard 3040-05 **The students will identify and group samples of the three classes of rocks, tell how each is formed, and perform tests to determine properties of rocks.**

Objectives

3040-0501. Classify rock samples into three groups: igneous, sedimentary, or metamorphic.
3040-0502. Describe how rocks in each of the three groups were formed.
3040-0503. Determine the relative hardness of several rocks by performing a scratch test using a fingernail, a penny, a piece of broken glass, etc.
3040-0504. Identify rocks containing limestone, e.g., place a drop or two of vinegar on the rock; those that "fizz" contain limestone.

Standard 3040-06 **The students will determine the composition of soil, identify properties of soil, and discuss the importance of soil conservation.**

Objectives

3040-0601. Describe what materials form soils, e.g., finely ground rock and humus.

3040-0602. Experiment to determine which kind of soil retains the most water, loam, clay, or sand.
3040-0603. Investigate factors that increase soil productivity.
3040-0604. Observe and record the differences between topsoil and subsoil.
3040-0605. Determine causes of soil erosion.
3040-0606. Describe methods of soil conservation.

Standard 3040-07 **The students will identify basic cloud formations, describe how precipitation is formed, record daily weather conditions, and discuss the role of satellites in predicting weather.**

Objectives
3040-0701. Identify basic cloud types: cirrus, cumulus, and stratus.
3040-0702. Describe how precipitation is formed in the water cycle.
3040-0703. Observe, measure, and record daily weather conditions on a graph. Do this for temperature, pressure, wind direction, and amount of precipitation.
3040-0704. Explain how information from satellites is used to predict weather.

Standard 3040-08 **The students will identify the basic components of the solar system; describe their relative sizes, positions, and movement patterns.**

Objectives
3040-0801. Identify the relative sizes and the positions of the sun, planets, and moons. (Students should not be required to learn diameter, distance, and other specifics.)
3040-0802. Summarize the differences between stars and planets.
3040-0803. Describe some of the characteristics of the earth that are related to its position in the solar system, e.g., magnetic forces, length of year, temperature.
3040-0804. Compare the earth's characteristics, e.g., length of year, temperature with those of the planets Mercury and Jupiter.
3040-0805. Explain that the objects in our solar system are in motion, that they rotate on their own axis, and that they revolve around the sun.
3040-0806. Define natural and man-made satellites and discuss their role in space exploration.

SCIENCE LEVEL 5

SIS NUMBER: 3050
SIS CODE: SI

Core Standards of the Course

Standard 3050-01 **The students will identify and describe structural (anatomical) and behavioral adaptations in animals, propose reasons for the extinction of animal species, and summarize animal conservation practices.**

Objectives

3050-0101. Identify examples of structural adaptations in animals (the beak and talons of an eagle, the trunk of an elephant, the teeth of a shark, the neck of a giraffe).
3050-0102. Describe some behavioral adaptations of animals (fawns remaining motion less when danger is near, a mother bera protecting her cubs, etc.).
3050-0103. Distinguish between hibernation and migration and cite examples of animals that do each.
3050-0104. Examine the role of environmental changes in the appearance and extinction of animals.
3050-0105. Discuss some of the current animal conservation practices and their value.

Standard 3050-02 **The students will describe the major characteristics of plant parts, explain how plants can be reproduced, and describe structural adaptations exhibited by some plants.**

Objectives

3050-0201. Describe the relationship beteen flowers and seeds.
3050-0202. Distinguish between pollination and fertilization.
3050-0203. Identify the characteristics of a fruit and list several examples.
3050-0204. Demonstrate that some plants can be started from leaf and steam cuttings.
3050-0205. Explain the structural adaptations of cacti, water lilies, Venus's flytraps, or other plants which help them to survive in their particular environments.

Standard 3050-03 **The students will give examples of the different states and forms of energy, identify different energy transformations, and discuss renewable and nonrenewable energy resources.**

Objectives

3050-0301. Distinguish between the two energy states—kinetic and potential.
3050-0302. Identify several sources of energy, e.g., hydropower, nuclear, geothermal, fossil.

3050-0303. Identify different forms of energy, e.g., heat, light, electrical, mechanical, chemical, nuclear.
3050-0304. Describe examples of energy being transformed from one form to another.
3050-0305. Trace the energy stored in foods, fuels, wind, and water power back to the sun.

Standard 3050-04 **The students will summarize the characteristics of magnets, demonstrate the relationship between electricity and magnetism, and construct an electromagnet.**

Objectives
3050-0401. Review the characteristics of magnets.
3050-0402. Demonstrate that an electric current flowing along a wire has a magnetic field around it.
3050-0403. Distinguish between a permanent magnet and an electromagnet.
3050-0404. Construct an electromagnet.
3050-0405. Discuss how electromagnets are used.
3050-0406. Describe the function and properties of a magnetic compass.

Standard 3050-05 **The students will identify atoms, elements, compounds, and mixtures; inferthat all solids, liquids, and gases are made up of atoms and molecules and that each atom and molecule is different from every other atom and molecule.**

Objectives
3050-0501. Show the location of a proton, neutron, and electron in an atom model.
3050-0502. Describe the relationship between an atom, element, compound, and mixture.
3050-0503. Infer that the smallest particles of an element (copper or iron, for example) which still has the properties of that element is an atom.
3050-0504. Infer that the smallest particle of a compound (sugar or salt for example) which still has the properties of that compound is a molecule.
3050-0505. Explain that the state of matter (solid, liquid, or gas) is dependent upon the distance between molecules.

Standard 3050-06 **The students will identify and compare the basic characteristics of light and describe images formed by different mirrors and lenses.**

Objectives
3050-0601. Classify materials into one of the three groups: opaque, transparent, or translucent.
3050-0602. Demonstrate differences between reflected and absorbed light.
3050-0603. Use a concave and a convex lens to demonstrate how light is refracted (bent) as it passes through each lens.

3050-0604. Use a prism, or other means, to demonstrate that white light is a mixture of all colors, and determine the order of colors in a spectrum or rainbow.
3050-0605. Explain the use of mirrors and lenses in instruments such as eyeglasses, cameras, telescopes, and flashlights.
3050-0606. Use a lens to focus an object on a flat surface; interrupt the direction of focus with a mirror.

Standard 3050-07 **The students will demonstrate the movements of the earth, sun, and moon; describe how these movements cause night and day, changes in the seasons, different phases of the moon, and eclipses; and show how they are used to measure time.**

Objectives
3050-0701. Define the terms rotate, revolve, and orbit.
3050-0702. Demonstrate what motion of the earth causes night and day.
3050-0703. Describe how the length of the year on the earth is determined.
3050-0704. Describe how change in the position of the earth's orbit and tilt of the axis produces the four seasons.
3050-0705. Explain what causes the moon to appear in different phases (shapes) each month. (Could be illustrated with a model.)
3050-0706. Identify factors creating solar and lunar eclipses.

Standard 3050-08 **The students will identify natural resources and discuss conservation and pollution of these resources.**

Objectives
3050-0801. Describe the uses and conservation of renewable and nonrenewable resources.
3050-0802. Describe causes and effects of air, water, and land pollution.
3050-0803. Explain methods for controlling air, water, and land pollution.

SCIENCE LEVEL 6

SIS NUMBER: 3060
SIS CODE: SI

Core Standards of the Course

Standard 3060-01 **The students will describe one-celled organisms; compare bacteria, viruses, and protozoans; and discuss ways some diseases are spread.**

Objectives

3060-0101. Draw and label one-celled organisms: algae, yeast, protozoans.
3060-0102. Describe how algae is important to a basic food chain.
3060-0103. Identify the protozoans: amoeba and paramecia.
3060-0104. Identify uses of bacteria.
3060-0105. Differentiate among bacteria, viruses, and protozoans.
3060-0106. Examine ways in which some diseases are spread.

Standard 3060-02 **The students will identify and classify some common plants, summarize the function of plant parts in food making, and describe photosynthesis.**

Objectives

3060-0201. Classify plants according to variations in a single characteristic, e.g., simple or compound leaf, smooth or rough bark, root systems.
3060-0202. Describe the function of leaves, roots, and stems in the process of food making by green plants.
3060-0203. Discuss the materials and conditions that are essential for photosynthesis.

Standard 3060-03 **The students will classify the groups of arthropods, describe metamorphosis and explain the proliferation of insects.**

Objectives

3060-0301. Describe the characteristics of arthropods.
3060-0302. Classify the major groups of arthropods—insects, crustaceans, arachnids, millipeds, and centipedes, e.g., number of leg pairs, body segments, wings.
3060-0303. Compare complete and incomplete metamorphosis.
3060-0304. Explain the proliferation of insects, e.g., reproductive rate, adaptability.

Standard 3060-04 **The students will measure temperatures, infer a relationship between heat andthe state of matter, demonstrate how heat travels, and distinguish between heat conductors and insulators.**

Objectives

3060-0401. Read accurately thermometers calibrated in either the Fahrenheit or Celsius scale.

3060-0402. Explain how gases may be changed to liquids and liquids changed to solids in relationship to heat.
3060-0403. Differentiate between heat conductors and insulators and their functions.
3060-0404. Compare conduction, convection, and radiation.
3060-0405. Devise an investigation to show that some things are better conductors of heat than others.
3060-0406. Show that heat travels through liquids and gases by convection currents.
3060-0407. Infer how heat travels from the sun to the earth.

Standard 3060-05 **The students will measure factors that influence the weather and describe why these factors change, propose reasons for the movement of air masses, and forecast the weather.**

Objectives
3060-0501. Use a barometer to measure air pressure.
3060-0502. Explain what causes air pressure and why air pressure changes.
3060-0503. Suggest possible reasons for the uneven heating of the earth's surface.
3060-0504. Identify factors that cause air masses to move.
3060-0505. Discuss the formation and movements of fronts.
3060-0506. Measure humidity.
3060-0507. Determine wind speed.
3060-0508. Describe the conditions that lead to the formation of dew or frost.
3060-0509. Make weather forecasts for several days using barometric pressure readings, wind speed and direction, temperature, and cloud formations.

Standard 3060-06 **The students will compare the operational principles of jets, rockets, and satellites; identify uses of man-made satellites; and describe conditions that astronauts encounter in space.**

Objectives
3060-0601. Distinguish between a jet engine and a rocket engine.
3060-0602. Cite examples of the "action-reaction" principles in everyday events.
3060-0603. Explain what keeps a satellite in orbit.
3060-0604. Review the difference between natural and man-made satellites.
3060-0605. Discuss some conditions under which astronauts must work and some of the safety devices that are used to protect them.
3060-0606. State several reasons why astronauts must wear space suits when they are outside of the space capsule.

Standard 3060-07 **The students will identify and describe the layers of the earth, geological eras, agents of change, and the formation and characteristics of fossils.**

Objectives
3060-0701. Identify the crust, mantle, and core of the earth.

3060-0702. Identify and describe the geological eras: Precambrian, Paleozoic, Mesozoic, and Cenozoic.

3060-0703. Review agents that change the earth, e.g., volcanoes, earthquakes, glaciers, erosion, weathering.

3060-0704. Infer changes that may have produced fossils.

3060-0705. Classify types of fossils, e.g., mold, cast.

3060-0706. Investigate the sequence of life that fossils reveal.

3060-0707. Investigate methods for dating fossils.

Standard 3060-08 **The students will show the relationships between rocks and minerals; classify and list uses of minerals.**

Objectives

3060-0801. Demonstrate that rocks are made up of minerals.

3060-0802. Classify the minerals in a variety of rocks on the basis of color, luster, and crystalline shape.

3060-0803. List several ways that minerals are used.

Resources to Meet Core Objectives (Component 5.1)

Core standards and objectives may be achieved in a variety of ways. The Utah Elementary Science Resource Guide (Daugs, 1986) contains a variety of means to achieve core objectives. This document is available at Edith Bowen Laboratory School on computer discs and also from Dr. Donald Daugs, Dept. of Elementary Education, Utah State University in print-out form.

A sample from the Guide follows:

SCIENCE STANDARD: 1 **CORE IDENTIFICATION NUMBER** ——— **3000-0101**

The students will use the five senses to gather and compare information about their natural environment.

OBJECTIVE: 1

Determine the shape, size, and texture of a common object (e.g., ruler--rectangle; nesting blocks--large, small; sandpaper--rough; cotton--soft).

Standard and Objective as they appear in the Core.

VOCABULARY:

hard
rough
senses:
perception
touch
shape
geometry
size
smooth
soft
texture
painting (texture)
touch

Vocabulary: If underlined, it will be found in most encyclopedias.

BASIC PLAN 1

Lesson plans that require no textbook.

Materials/Preparation:

large cardboard box with lid (shoebox size or larger)
chart paper--"My Five Senses"
items for box:
  feather
  cotton ball
  sea shell
  orange
  pine cone
  marble
  crayon
  rubber ball
  sand paper
picture of a hand and the word "TOUCH"

Prepare a "Feely Box" to be used with the discussion on the sense of touch. Cut a small hole in the end of the box so the students can reach into the box without seeing the contents, or use a cylindrical box such as a "Quaker Oats" container and attach a sock with the toe cut out.

Prepare a chart labeled "My Five Senses". The appropriate picture and word will be added after each strategy in this standard has been discussed.

Procedure:

1. Begin by discussing the sense of touch and how our bodies help us feel things. Use these questions:
   What part of your body do you use to feel an object?
   What can you tell about an object by feeling it?
2. Place objects of various sizes, shapes, and textures into the "feely box" that have been prepared. Have the student take turns feeling an object in the box and describing how it feels. Remove the object and the other students will determine if the object has been described correctly. The objects might be grouped according to how they feel (e.g., hard, soft, rough, flat).
3. After discussing the sense of touch, a picture of a hand and the word "touch" will be added to the chart. Explain that the hands are the main part of the body that touch, although the whole body is sensitive to touch.

BASIC PLAN 2

Materials/Preparation:

box with a hole on each end (can be the same box that was used in Plan 1)
a variety of objects in pairs: (e.g., two socks, two rocks, etc.)

- apples
- cans
- nails
- pencils
- pinecones
- rings
- rocks
- sacks
- sandpaper
- silk scarves
- spoons

Procedure:

1. Place a variety of "paired" items in the box.
   Select a child to put ahand in each end of the box. They will feel the items inside until they think they have found a "pair".
   Before the child pulls out the "pair", have him/her describe the object (i.e., Is it rough? Is it smooth?). Discuss texture, size, and shape. Have each child in the class guess what the object is and pull out the pair to show the rest of the class. Let each child have a turn.

BASIC PLAN 3

Materials/Preparation:

collection of junk

Procedure:

1. Divide class into small groups and provide each group of children with a collection of junk.
2. Let them decide all the ways they can classify the junk: (e.g., size, shape, texture, etc.)

References/Materials/Resources:

Merrill, ACCENT ON SCIENCE, 1985,
Readiness, T.E., pp. 2-17.
Merrill, ACCENT ON SCIENCE, 1985
Readiness Resource Book, pp. 1, 10-14.
Merrill, ACCENT ON SCIENCE 1, 1985,
T.E., pp. 4-9, 20-21, 26-29.
Merrill, ACCENT ON SCIENCE 1, 1985,
Resource p. 7.
Merrill, ACCENT ON SCIENCE 1, 1985,
Activity Book, pp. 3, 9-14.
Merrill, ACCENT ON SCIENCE 2, 1985,
Activity Book, pp. 3, 9-14.
Coronado, SCIENCE AND TECHNOLOGY, "Things Around Us", 1985, pp. 1-22.
Heath, Level 1, 1985, pp. 1-5.
Rand McNally and Co., SCIIS, 1978,
Level 0 Beginnings, pp. 12-19, 42-49.
PROJECT WILD, Learning to Look, Looking to See, p. 181
PROJECT LEARNING TREE, Expanding Sensory Perception, p. 12.

Related Curriculum Areas/Extensions:

Math, 0-1-1, Classification
Activities for Science, Math, an d Language Arts.
Classify according to color, shape, size, texture, function, number, and flavor.

Ties to other curriculum areas.

Textbook resources that have material that will achieve the objective.

The Role of the Computer (Component 5.1)

The Utah Elementary Science Resource Guide is contained on computer files. One of the purposes of this storage procedure is to expose students to the potential of computers for curriculum management. These files are located in the hard disk and Apple II soft disk file at Edith Bowen Laboratory School. They may be used at any time and should be used as part of Level III practicum. Log-on procedures for use of these files can be obtained from the Edith Bowen School office.

The section that follows provides a rationalefor use of these files.

Rationale:

1. To identify and articulate all of the Utah State Core Curriculum in science in grades K-6.
2. To assist teachers and prospective teachers on science lesson planning and development via a ready reference of resource ideas, methods and materials.
3. To integrate science concepts, principles, facts, and skills into other subject areas in grades K-6.
4. To correlate and key the Utah State Science Core Curriculum to a variety of science textbooks, encyclopedias, and other available sources for background information and additional ideas and methodologies.
5. To promote sound science instruction.

REFERENCES

Daugs, Donald R. Utah Elementary Science K-6 Resource Guide, Utah State University, Logan, Utah, 1986.

Utah State Board of Education, Core Curriculum, Grades K-3 and 4-6, Salt Lake City, Utah, 1986.

Chapter 7
HISTORICAL PERSPECTIVE

How did we get where we are? (Component 6.2)

In this section, you will receive a historical perspective on elementary science curriculum changes that have occurred over the past fifty years. Some things have not changed much in that time period. Then the textbook was the foundation of science teaching, in most places it still is today. For ease in discussion of elementary science curricula, they are divided into "generations". First generation material may still be alive today, but second, third, and fourth generation material did not exist prior to 1957.

First Generation

First generation materials are characterized by having one main author and can be used as readers. This is the traditional science textbook. The classic example is Concepts in Science by Paul Brandwein. This textbook series dominated the market from the 1940's to well into the 1970's.

The major changes that have occurred in first generation curricula is that the number of authors has increased, the quality of pictures have improved, and demonstrations and activities have been added. Today, most elementary teachers teaching science still rely on a textbook.

Second Generation

In 1957, Sputnik provided the impetus for change from first generation to second generation elementary science. Second generation materials generally require little or no reading, have many authors, and are very good science. Often referred to as the alphabet soup curricula, they include ESS, SCIS, and SAPA.

Large amounts of federal money was poured into developing and implementing these programs. However, they never were used as widely as first generation materials. Where used, they now are probably gathering dust in a closet. When funding for materials ceased, so did emphasis on these programs.

Third Generation

Third generation materials are characterized by being multidisciplinary in nature, have many authors, may or may not include text material, and are privately funded. ESSP and MAPS are examples of third generation elementary science curricula. These programs appeared in the late 1970's, partly as a response to discontinued federal funding for second generation programs.

Project Wild and Project Learning Tree are examples of recent privately-funded curricula that also fit the third generation criteria. These programs emphasize a multidisciplinary approach to environmental education.

Fourth Generation

Fourth generation elementary science curricula are locally developed by teams of teachers. They may or may not be multidisciplinary in approach. Box Elder and Jordan school districts have developed their own programs. Such programs are usually low-budget, non-text oriented, and very effective because they belong to the teachers.

Fifth Generation

We are on the verge of a transition to curriculum that integrates science, technology, and society concepts. These programs are presently receiving foundation and federal funding and will be on the market shortly. Technology will play an increased role in both course delivery and course content.

Historical Summary of Science Education in the Elementary School
(Component 6.2)
(For reference only; do not memorize)

Before 1850 Children recited and memorized factual knowledge.

Purpose: Support for theology.
Criticism: Dull, boring memorization and theological base.

1850's Two distinct influences on American Science Education:

1. British—Instructional literature for private tutors or parents.
Purpose: Children's observations and study of nature.
Criticism: Obtainable only for upper economic classes.

2. German—Pestalozzian "object teaching". In America—the Oswego, N.Y., "Method".
Purpose: Observation, description, and memorization of animate and inanimate objects for preparation for studying science in upper grades.
Criticism:
a. Emphasis upon description: interpretation and understanding of events and phenomena neglected.
b. Extremely fragmented—lacked order.
c. Capricious due to chance selection of "objects".

1870's First Organized Science Program in Elementary School

Great influence of Herbert Spencer and rise of popular interest in science and technology in America; science pushed as a field of study in elementary schools.

Purpose: Introduction of formalized science curriculum, William T. Harris, St. Louis, MO, Public Schools—first organized curriculum in elementary school, based upon mastering scientific classification and terminology.
Criticism: Old patterns of teaching learning not suited to changing times and data beginning to appear on how children learn.

1890's Nature Study Movement

Influenced by National Education Association, William F. Harris, G. Stanley Hall, Colonel Francis W. Parker, Henry H. Strait, Wilbur S. Jackman, Liberty Hyde Bailey.

Purpose:
a. Emphasis upon laboratory and other direct experiences.
b. Need for special training for science teachers.
c. Nature study movement—helping children learn about and appreciate their environment.
Criticism:
a. Emphasis almost exclusively on biological sciences.
b. Fragmented—overemphasis upon identification and isolated bits of data.
c. Overemphasis on sentimental, emotional, and esthetic explanations.
d. Did not challenge thinking of younger children.

1920's Methodology and Utilitarian Aspect of Science

Influence of Charles Saunders Peirce, William James, John Dewey, Gerald S. Craig.

Purpose:
a. Emphasis upon pragmatism—meaning of concepts to be found in the working out process of experience.
b. Methods of science equal to, or greater than, actual information gathered.
c. Cognitive aspects also stressed attitudes, appreciations, interests.
d. Utilitarian aspect of science education as related to health, safety, economy, and so on.
Criticism:
a. Tendency to overemphasize attitudes, appreciations, interests.
b. Overemphasis upon methodology of science detracted from science content.
c. Overemphasis upon utilitarian view of science and technology.

1930's - Present Curricula Based on Sequential Major Science Principles and Their Applications: "First Generation"

Purpose:
a. Sequence and articulation of science programs K-12.
b. Emphasis upon major generalizations or principles of science.
c. Emphasis upon understandings and applications of science.
d. Textbook approach.
Criticism:
a. Overemphasis upon practical application of principles.
b. Overemphasis upon personal and social aspects.

1950's-60's Teaching Science as Process and Products—Discovery Approach and Conceptual Schemes Curriculums:

Influence of National Society for the Study of Education (59th Yearbook in 1960), National Science Teachers Association, and many individual curriculum, experiments, such as PSSC, wholly or partially supported by the American Association for the Advancement of Science, the National Science Foundation, and other public and private sources.

Purpose:
a. Stress helping children learn science information, skills, attitudes to function as intelligent world citizens.
b. Stress characteristics of science process and products.
c. Use structure and content of scientific disciplines for shaping curriculum.
d. Greater use of data on how children learn for selection of activities for teaching science.
e. Stress teaching science through discovery approach.
f. Scientists, learning specialists, and classroom teachers must work together on preparation of science curriculums and instructional materials.
Criticism:
a. Process may be overemphasized to the exclusion of science content.
b. Structure of conceptual schemes may be too inflexible and rigid.
c. Work aimed at average and above-average students, not slow learner and "ghetto" children.
d. Teachers need inservice work to improve skills.

1970's-1980 Influence of National Science Teachers Association and "second generation" science curriculum projects such as SCIS, ESS, and SAPA.

Purpose:
a. Stress teaching science with a holistic approach.
b. Integrating science with other subjects.
c. Greater awareness of the importance of teacher's and student's feelings and attitudes in teaching science.
d. Stress humanistic teaching of science.
e. Greater integration of values clarification in science teaching.
f. Use of societal issues and controversies for themes in science teaching.
g. Teaching science on three levels: facts, concepts, and values levels.
h. Stress ecological and environmental focus in science teaching.
i. Stress science teaching for all children—handicapped, gifted, and so on.
Criticism:
a. Need for science curricular materials integrating science and other sub jects, including values level.
b. Teachers need inservice work to develop skills in morehumanistic, values-laden science teaching.

1976-Present “Third Generation” Influence of withdrawl of federal funding and reaction to “heavy” science of second generation materials.

Purpose:
a. Fun, interesting, and relevant elementary curriculum.
Criticism:
a. Does not fit most state curriculum.
b. Multidisciplinary approach.
c. Non-traditional.

1980-Present “Fourth Generation” Locally developed curriculum.

Purpose:
a. Meets local needs.
b. High teacher commitment.
Criticism:
a. Often re-invents the wheel.

1987-Present “Fifth Generation” STS.

Purpose:
a. Science for tomorrow.
b. Reflects current status of what is happening in science and technology.
c. Integrates STS.
d. Drops traditional disciplines.
Criticism:
a. Does not fit most state science guidelines.

REFERENCES

Brandwein, Paul P. et. al. Concepts in Science. Harcourt Brace Jovanovich, various editions.

Cain, Sandra E. & Evans, Jack M. Sciencing. Charles E. Merrill, 1984, pp. 46-107 for discussion of second generation curricula, pp. 109-142 for discussion of first generation curricula.

Project Learning Tree, The American Forest Council, Washington, D. C., 1987.

Project Wild, Western Regional Environmental Education Council, Boulder, CO, 1983.

Chapter 8
THE MULTIDISCIPLINARY APPROACH

A Multidisciplinary Approach Philosophy (Component 6.3)

One of the major failings of earlier elementary science curricula has been lack of real world relevance. Science traditionally has been taught as a discipline divorced from ties to the rest of the curriculum.

Second generation elementary science curricula were great science, but neither teacher nor students really related well to many of the topics or approaches. They were taught as science for science sake. Science at the elementary level should be taught for various reasons. One, it is a basic; two, it is a great motivator for work in reading and writing; three, it can be activity oriented (fun). Mechling and Oliver (1983) cover in detail the whys and wherefores of science as a basic skill.

One of the earliest attempts at a multidisciplinary approach to elementary science was the Elementary School Science Program published by Lippincott. This program came out in 1976, contained fun, multidisciplinary activities, but did not sell well. It was probably ten years ahead of its time.

Current trends show evidence of integrating science with the rest of the curriculum. Sample activities that follow provide examples of the multidisciplinary approach.

REFERENCES

Mechling, Kenneth R. & Oliver, Donna L. Science Teachers, the Basic Skills, National Science Teachers Association, Washington, D. C. 1983.

The Elementary School Science Program, J. B. Lippincott Co., Philadelphia, 1976.

Materials You Furnish	Kit Materials	Notes and Suggestions	Recommended Student Grouping
Chalkboard Crayons, 1 per student Scissors, 1 pair per student 35 mm slide projector Activity Pages 3a and 3b	†Daylight slides 3a-3h Paper fasteners, 1 per student Paper plates, 15 cm (6 in.), 1 per student Tagboard, 2 x 10 cm (approximately 1 x 5 in.), 1 per student	The tagboard is for use in making clock hands. The graphing task on Activity Page 3b spans a week's time.	Ones

Average time: 72 min.
Minimum time: 45 min.
Maximum time: 110 min.

INTERACTIVITY GOAL

The student will infer order and variation in change.

CONTENT OBJECTIVE

The student will recognize the cyclical nature of daily activities.

SCIENCE SKILLS

The student will —
observe patterns of daily activities;
measure time;
graph data;
order or classify daily activities and time.

MULTIDISCIPLINARY ASPECTS

Art
Sketching
Health
Understanding the importance of daily health routines
Language arts
Oral and written communication
Pantomiming
Reading
Mathematics
Constructing a clock face
Graphing
Measuring
Telling time
Social studies
Identifying adult roles
Identifying child roles

KEY VOCABULARY

cycle, pantomime, symbol

PURPOSE

During the activity students will be involved in discovering the patterns and cyclic nature of their daily activities.

TEACHER ROLE

Arrange your teaching schedule so that the graphing activity starts on a Monday, if possible. Ask questions to bring out student observations of daily life activities that they take for granted and may not think to mention without your intervention. Help those who need it graph their daily activity data.

Follow up the science activity with related and suggested language arts, health, and art options, or insert the optional activities into the science activity at an appropriate time.

TEACHER PREPARATION

1. See that the clock faces needed in this activity are made ahead of time by the students, during a math class or at some other convenient time. See Activity Page 3a for directions.
2. You may want to construct one clock face the students can use as a model to look at while constructing their own.

BEGINNING THE ACTIVITY

Group the children near the chalkboard.

TEACHING STRATEGIES

POSSIBLE STUDENT BEHAVIORS

WHAT IS THE FIRST THING YOU DO EVERY MORNING?

Respond, "Wake up," "Get up,"

WHAT ELSE DO YOU DO BEFORE YOU COME TO SCHOOL?

Respond, "Get dressed," "Brush my teeth," "Eat breakfast," "Comb my hair," "Take my medicine," and so on.

WHAT ARE SOME THINGS YOU DID AFTER SCHOOL YESTERDAY?

Respond, "Played ball," "Saw Uncle Stan," "Went shopping," and so on.

HERE ARE SOME PIECES OF CHALK. TAKE TURNS WRITING SOME OF THE THINGS YOU DID YESTERDAY ON THE CHALKBOARD. DON'T FORGET SCHOOL.

Write some of yesterday's activities on the chalkboard.

Try to call on each student to write at least one thing that he/she did the day before.

LET'S SEE IF FROM ALL THESE NOTES OF YOURS WE CAN MAKE A LIST OF THINGS THAT *ALMOST ALL OF US* DID. WHAT ARE SOME THINGS WE COULD PUT IN THAT LIST?

Respond, "Got up," "Ate breakfast," "Went to school," "Had lunch," and so on.

Make this ordered list of daily activities as students suggest some of the items common in their day. Then suggest pantomimes of these activities, which may help the students recall even more things they did. (Have they listed watching TV, bathing, and so on?)

*Equipment Kit Items †Media Kit Items Unmarked items are in the Consumable Kit

WHO WOULD LIKE TO PANTOMIME WHAT THEY DO WHEN THEY WAKE UP AND GET OUT OF BED IN THE MORNING?

A student will pantomime yawning, stretching, stepping out of bed, brushing teeth, and so on.

Pantomime time

WHO WOULD LIKE TO PANTOMIME THE WAY THEY ATE BREAKFAST?

A student will pantomime breakfast eating.

Pantomime time

Continue questioning and inviting pantomimes with such things as eating lunch, watching TV, playing, going to bed, and so on. Allow as many different students, who wish to volunteer, to pantomime an activity. Then have all return to their seats.

NOW TAKE OUT YOUR CLOCK FACES.

Students will get their clock faces.

Materials
Daylight slides 3a-3h
35 mm slide projector
Chalkboard

Project daylight slide 3a on the chalkboard.

SET THE HANDS OF YOUR CLOCK TO SHOW WHEN YOU THINK THIS HAPPENED.

Students will set clock hands to seven o'clock, seven-thirty, and so on.

Clock setting time

There is no one "right" time. Responses will vary as eating times do.

Project daylight slide 3b on the chalkboard.

WHAT TIME DO YOU THINK IT IS IN THIS PICTURE?

Students will set clock hands.

Again, the times suggested by the students will vary. Accept all their responses.

Continue in this way with the rest of the daylight slides. Students may point out that it is difficult to know what time it is when the baby is napping, or when a student is reading a book. Assure them that they can choose whatever time they think is appropriate. There is no one "right" answer.

After you have used all the slides, introduce the task for the coming week.

FOR THE NEXT WEEK EACH ONE OF US WILL TRY TO KEEP TRACK OF THE TIMES WHEN WE GET UP, EAT, AND GO TO BED. ACTIVITY PAGE 3b WILL HELP US DO THIS.

Materials
Activity Page 3b

Make certain each student has Activity Page 3b.

THE DAYS OF THE WEEK GO ACROSS THE BOTTOM OF THE GRAPH. WHAT DAY DOES IT BEGIN WITH?

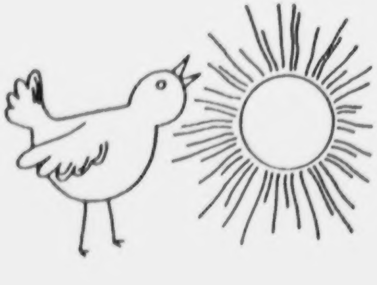
Respond, "Monday."

ON THE FRONT OF THE ACTIVITY PAGE ARE THE 12 HOURS FOLLOWING MIDNIGHT, UNTIL NOON, AND ON THE BACK ARE THE 12 HOURS FROM NOON UNTIL MIDNIGHT AGAIN. THERE IS A BOX FOR EACH HOUR OF THE DAY.

You may have to spend some time with the students in helping them understand the a.m.-p.m. (morning-afternoon) concept.

TO SHOW ON THE CHART WHEN WE WAKE UP, WE NEED A SYMBOL THAT WE CAN DRAW IN THE SMALL BOX AT THAT TIME. THAT SYMBOL WILL MEAN "WAKE-UP TIME." WHAT WOULD BE A GOOD PICTURE TO DRAW THERE?

Students' drawings may look like this:

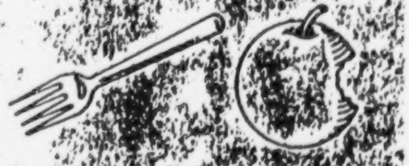


Let volunteers come to the board to draw appropriate symbols that other class members may see.

Accept all suggestions.

WHAT COULD BE OUR SYMBOL FOR "EATING TIME?"

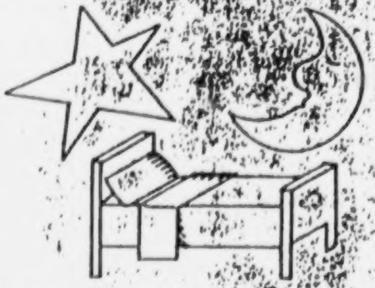
Draw.



Again, accept all suggestions sketched on the board.

WHAT SYMBOL WOULD YOU USE FOR "BEDTIME?"

Draw.



Accept all symbols drawn on the chalkboard.

NOW YOU CHOOSE THE THREE SYMBOLS YOU WOULD LIKE TO USE ON YOUR OWN GRAPH. DRAW YOUR SYMBOL FOR "WAKE-UP TIME" IN THE BIG BOX ON THE TOP LEFT-HAND SIDE OF ACTIVITY PAGE 3b. DRAW YOUR SYMBOL FOR "EATING TIME" IN THE MIDDLE BOX NEXT TO WAKE-UP TIME. DRAW YOUR SYMBOL FOR "BEDTIME" IN THE LAST BOX.

Drawing and graphing time

Leave time for students both to draw and to color (if they wish to do so) their three basic symbols.

ON MY GRAPH (hold up your copy of the activity page), I HAVE USED THE SYMBOL_____FOR WAKE-UP TIME. I WOKE UP THIS MORNING AT O'CLOCK. SO I WILL PUT MY SYMBOL IN THE SPACE NEXT TO_____O'CLOCK. (Show the students your chart.) NOW I WANT EACH OF YOU TO PUT YOUR WAKE-UP SYMBOL IN THE PLACE THAT SHOWS WHEN YOU WOKE UP THIS MORNING.

Draw in wake-up symbol.

Move among the students to help them as needed. The symbols can be located approximately at the proper time. Exact placement is not necessary. Don't worry about quarter- or half-hour differences in placement.

MY SYMBOL FOR EATING TIME IS______. I HAD MY BREAKFAST AT_____O'CLOCK. I'LL PUT MY EATING TIME SYMBOL IN THAT SPACE.

Demonstrate on your activity page.

NOW DRAW YOUR OWN EATING TIME SYMBOL ON YOUR CHART.

Draw the symbol.

EACH DAY THIS WEEK I WILL REMIND YOU TO ENTER YOUR SYMBOLS ON YOUR DAILY GRAPH.

A good place to stop

One-week recording time

Go on to optional and succeeding science activities, during each of which you will remind students daily about their graphs. When the graphs are complete, display them on a bulletin board where they can be seen by all the students.

YOU DID A FINE JOB OF KEEPING YOUR GRAPHS. WHAT CAN WE LEARN FROM LOOKING AT ALL THE GRAPHS?

Respond, "There is a lot about them that's the same," "Most of us sleep late on Saturday," "We don't all go to bed at the same time," and so on.

Encourage a variety of comments focusing on the cyclical nature of daily activities and the variations between individuals and among the group as a whole.

OPTIONAL ACTIVITIES

1. Some students may enjoy writing and sharing poems and stories about the five central daily activities of sleeping, waking, eating, playing, and working.

Here are some poems you might use to spark discussion and creative writing:

"A Child's Day—Part II," Walter de la Mare
"Two in Bed," Abram Bunn Ross
"Tired Tim," Walter de la Mare
"Check," James Stephens
"Automobile Mechanics," Dorothy Baruch
"Indian Children," Annette Wynne
"School is Over," Kate Greenaway
"Sliding," Myra Cohn Lingston
"The Swing," Robert Louis Stevenson
"Follow the Leader," Harry Behn
"Smells (Junior)," Christopher Morley
"The Cupboard," Walter de la Mare
"The Toaster," William Jay Smith

All of these poems are included in *Time For Poetry*, compiled by May Hill Arbuthnot and Shelton L. Root, Jr., Scott, Foresman and Company, Glenview, Illinois, 1968.

2. In the daily activity cycles, call attention to the good health habits that occur in the cyclical daily patterns (brushing teeth, bathing, combing hair, and so on). Discuss these good health habits and the why's of each of them.

3. Remind students that we change as we grow. Have them sketch themselves as they think they were as babies, on one half of a sheet of drawing paper, and sketch themselves the way they look today on the other half of the paper. Have the class observe and compare the left-half pictures with the right-half pictures.

4. The daily activities of grownups, in a variety of careers, also have both similarities and differences. It might be worthwhile to ask some members of the community to visit the class and discuss what they do in the course of an ordinary work day. Selections from *All Around the Town*, Phyllis McGinley, J. B. Lippincott Co., Philadelphia, will emphasize the different routines going on simultaneously in a community (such as "D's the Dairy Driver", and "F is the Fighting Firetruck").

MICROTREK SCAVENGER HUNT

Objectives Students will be able to: 1) state that humans and wildlife share environments; 2) demonstrate that humans do not have exclusive use of environments; and 3) generalize that wildlife can be all around us even if we do not actually see or hear it.

Method Students go outside on a "scavenger hunt" for wildlife.

Background See "Wildlife Is Everywhere." The major purpose of this activity is for students to understand that people and wildlife do share environments. By investigating microenvironments or microhabitats, the students should be encouraged to generalize from the information they acquire to the whole of the planet, coming to the understanding in general terms that wildlife exists in all areas of the planet, in some form. In the deserts of the southern hemisphere, the oceans, tropical jungles, and cities of the earth; from the Antarctic snow fields to the glaciers of the Arctic region, wildlife exists in a variety of forms.

Materials hand lens, digging tool, pencil and mimeographed instruction sheet for each group of two to five students

Procedure

1. This is a wildlife scavenger hunt! The students will be given a list of things to find, and then will go outside and find different kinds of evidence that wildlife exists—even at school! (This activity can be done almost anywhere, with supervision—from city centers to parks to outdoor education sites. It is especially effective where students would not expect to find much wildlife.)

2. Divide the students into groups of two to five. Provide each group with a small hand lens, small digging tool, pencil, and instruction sheet. The instruction sheet could look something like the following:

Age: Grades 4—6 (and older)
Subjects: Science, Language Arts, Social Studies
Skills: analysis, application, classification, description, discussion, generalization, listing, observation, problem solving, reading, small group work, writing
Duration: 30 minutes to two hours
Group Size: small groups working simultaneously; any number
Setting: outdoors and indoors
Conceptual Framework Reference: I.B., I.B.1., I.B.2., I.B.3., I.B.4
Key Vocabulary: evidence, environments, wildlife

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WILDLIFE SCAVENGER HUNT

This is a scavenger hunt to look for evidence of wildlife!

CAUTION: Be careful not to kill any animals or damage their homes!

Find evidence that:

1. Humans and wildlife share environments.
2. Humans and wildlife must adjust to their environment, move to a more suitable environment, or perish.
3. Wildlife is all around us, even if we don't see or hear it.
4. Wildlife ranges from small in size, to very big.
5. People and wildlife experience some of the same problems.
6. People and wildlife both need a place to live.

3. Establish a length of time the students may be outside. This depends on how many things they are asked to look for. Go outside with them to supervise. You can use 15-minute blocks of time, with 15 minutes for every one or two things the students are looking for. For example, the six-item scavenger hunt used in the sample given in this activity could take anywhere from 15 to 45 minutes for the students to find their evidence. You could ask all of the students to find evidence for all of the items. Or, especially with younger students, you could assign each group just one of the things to find. Every group should return with some evidence. Evidence can be such things as small drawings on the mimeographed sheet or on extra paper the students take along. It can be word descriptions of what they see. It can be small samples they bring back to class, if they can bring samples without doing significant damage to the environment. You should provide paper sacks for evidence if they are going to bring things back.
4. Before sending the students outside, make sure the instructions are clear. Talk with the students about what wildlife is, contrasted with other animals like pets. Go through the list of things they are "scavenging" for, to make sure they have an understanding of what they will be looking for. Don't be too specific with your examples. (The most creative and conceptually solid solutions often come up in the face of ambiguity. The students are apt to find delightfully inventive and appropriate evidence, if allowed to be responsibly resourceful!) With the time limits established, open the door and begin "tracking!"
5. At the end of the designated time period, everyone should meet back at the classroom. Ask each of the groups to report on what they found.
6. What are some of the most interesting things the students felt they learned? Encourage the students to come to the generalizations that people and wildlife share environments, that wildlife is all around us, and in fact that wildlife in some form is in areas all over the planet.

Extensions

1. Creative writing!
2. Classify the types of wildlife found.
3. Tally the types of wildlife found, and the numbers of each kind of wildlife. (You can develop this tally into a pyramid of numbers to demonstrate that such a concept is real.)
4. Do microscope work with some of the samples found: for example, the underside of leaves with insect eggs, soil with a lot of plant matter, water, larvae, the inside of insect galls, bark, and a hollow plant stem.
5. See "Wild Words" and add drawings and descriptions to personal journals!

Evaluation

Name three things you saw, heard, or smelled which showed you that wildlife lives in the school area.

Name at least five different kinds of wildlife from five different areas on the earth.

In which areas on earth would you not be able to find any animals?

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Adopt-A-Tree

1

OBJECTIVE

Students will be able to list the basic characteristics of a tree as determined by their own observations.

ACTIVITY

This activity may be conducted as a class project; with a class divided into groups of three or four students each; or with students working individually. Several related activities are included in the pages that follow. They are indicated by Adopt-A-Tree in the titles.

This activity begins with adopting a tree (or trees) near or on your school site. If there are no trees nearby you might bring a potted tree to your classroom or try to have a tree planted on the school grounds. "Adopting-a-tree" is a valuable way to initiate a unit of study on trees with any age group.

The first visit

Visit the adopted tree(s).
Describe the tree as it is right now, today.
Look at its physical characteristics (size, leaf shape, bark color, and other features).
Look to see whether it is alive. How can you tell?
Look to see whether it appears to be asleep (dormant) or awake. How can you tell?
Listen to find out whether it makes any sounds.
Smell to find out whether it has an odor. Do different parts of the tree smell different — like bark, old leaves, new leaves? Think about whether the tree and its parts might smell different to you at other times of the year.
Think about how the tree got where it is and how new trees might come to join it.
Think about what other living things might need this tree for survival.
Think about what things the tree might need for its own survival.
Think about how long the tree might live.

Warning: Do not taste any part of the tree.

Repeat the visits throughout the year and compare observations made each time.

Look to see how the tree has changed.
Look to see in what ways the tree has remained the same.
Think and talk about what the tree might look like the next time you visit it.

SUBJECTS
- Language Arts and Humanities
- Science

GRADES
- K-6

PLT PRINCIPLES
- 1. Environmental Awareness
- 2. Diversity of Forest Roles
- 3. Cultural Contexts
- 6. Life-Support Systems
- 7. Lifestyles

CONCEPTS
- 1.1 Variety and Aesthetics Essential to Life Support
- 2.112 Forest as Resource Pool
- 3.42 Environmental Perspectives
- 6.2 Constancy of Biological Change
- 7.4 Creative Expression and the Environment

SKILLS
- I. Gaining Information
- II. Communication

1

(Continued)

After the first or more visits

Once back in the classroom and now that you and your students have adopted a tree, you might ask your students to tell you what they think a tree is. Accept all statements offered and be careful to record the students' exact words and phrases. List the statements on the chalkboard; discuss and make any changes suggested. When statements have been agreed upon, you and the students can put them together in the form of a poster, chart, or bulletin board.

Here are some sample statements:

A tree is a living thing.
A tree has many parts, just as people have many parts to their bodies.
There is the trunk (main torso), bark (skin), branches (arms, legs), leaves or needles (hair).
Trees have names. [The children can mention some names of trees.]
A tree has many uses. [You and the students may wish to list some.]
A tree interacts with and is dependent upon many other organisms, such as insects, mammals, and birds.

These initial activities can help you decide on follow-up projects by indicating what the students already know, what their interests are, and the kinds of additional information they might acquire.

EXTENSIONS

1. Brainstorm from 10 to 15 adjectives that could be used to describe a tree. These words can be used to write a poem (haiku or cinquain) or short paragraph about the tree.

(Continued)

2. Create and present a short story, puppet show, or play about the tree's parents and/or its offspring.
3. Imagine sounds you might hear near the tree. Can you hear leaves moving, animals, birds? Write a brief description of these sounds, inventing appropriate words, if necessary. Imagine you are looking at the tree. What colors and shapes do you see? Write a brief description, using your new words, of how the tree looks, smells, feels, and sounds.
4. Write a brief, imaginary conversation with your tree. What might your tree think, see, feel, hear, and smell? (You may wish to record the conversations on tape.)
5. Imagine you are a radio or television reporter interviewing a person, bird, or animal that lives in a forest or in a tree. Write down some questions you might ask, such as: How do you like your home? Who are your neighbors? What do you do for a living?
6. Take a tree to lunch. During lunch, consider these and other questions:

   What is it like under the tree?
   What animals visit the tree while you are there?
   What kind of help is the tree getting from people, if any (watering, feeding, pruning), and does it need that help?
   Why and when does it need help?
   What kinds of things, if any, are damaging the tree?
   Has the tree cast seeds? Have any seeds developed into seedlings?
   How does the tree take care of itself?
   How much of its history can you observe? Has it had any accidents (such as being hit by lightning)?
   Is the tree crowded by other trees or by buildings?
7. See whether your tree makes a shadow. Watch the changes in your tree's shadow at different times of the day and during different times of the year.
8. See whether you can use your tree, without hurting it, to make a sundial. Can it help you keep time?
9. Make paintings, drawings, or photographs of the shapes and shades of color you find when sunlight and shadows can be seen on and around your tree.
10. Describe your tree in enough detail so that someone else can recognize it. Share what you have learned by inviting someone else to visit your tree — and be sure to visit your friend's tree, too.

Chapter 9
THE SCIENCE LAB

Materials and Equipment (Component 6.4)

It has long been thought that the major factors contributing to lack of hands-on science in the elementary classroom were lack of teacher content background and deficient process skills. It is now suspected that another important factor contributing to lack of hands-on science is teacher unfamiliarity with the commonly used equipment and materials required for teaching elementary science.

The section that follows is a compilation of the equipment and materials listed in at least two of five of the most used elementary science textbook series. If any of these do not have immediate application value for you, then you should become familiar with that item (see instructor for procedures).

Most Commonly Used Elementary Science Materials and Equipment:

alcohol, iso-propyl (rubbing)
alligator chips
aluminum foil
aluminum potassium sulfate
ammonia solution
ant farm
aquarium
baggies, zip lock
baking soda
balance, primary/hoppers
balance, spring
balance, triple arm
ball, rubber
balloons, assotment
battery, size D
battery holder, D cell
beackers
bioscope, dynavision
bottle, spray trigger
bottle, wash
buttons, assortment
cages
calcium hydroxide
calculator
candle, birthday dripless
candle, warming
car, toy trucks
clamp, test tube
clay, modeling
clothespin
comb, hardrubber
compass
corks, various sizes
cornstarch
coverslips, plastic
cup, plastic 360 ml.
cylinder, graduated
daphnia
dropper, plastic
elodea
electric motor kit
feathers
feely bag, texture materials
file, metal
fishing line, nylon
flashlight
food coloring
funnel, utility
glucose, test tape
glue, white
goggles, protective
goldfish
gram mass set, brass 8 pc.
hammer/claw
hot plate
hydrogen peroxide
iodine
iron fillings
isopods
lemon juice
lens, concave
lens, convex
lens, double convex
lens, plane
light socket, minature brass
limewater solution
magnet, bar
magnet, glass
magnet, horseshoe
magnet, ring
magnifying glass
marble chips
marbles
meal worms
meter stick, wood
microscope
minerals, assortment
minerals hardness scale
mirror, concave
mirror, convex
mirror, plane
mitten, heat protection
nails, assortment
needle, steel embroidery
net, aquatic large
net, insect
net, nylon 3 inch
oil, vegetable
paper clips
paper graph
paper, litmus, blue
paper, litmus, red
pan, aluminum pie
petroleum jelly
pins, straight
pipe cleaners
pop bottles, 2 l. plastic
pop, flower plastic 3"
prism
protractor, 6" plastic, 180 DEG
razor blades, single edge
rhythm sticks
ring stand
rock assortment
rubberbands, assortment
salt, non-iodized
sand block
screwdriver
seeds, assortment
shoebox, plastic
slide projector
slides, microscope
soil, potting
spoons, plastic
sprinkler, plant
steel wool
straws, plastic
string, cotton
sugar, white granulated
support rings/clamps
swab applicator, cotton
switch, knife
tape, measure metric
terrarium
test tube, assortment
thermometer, -20-110C
toothpicks, flat
triangle/striker
trowel, golden
tweezers
umbrella, blade
vial plastic, snap cap
vinegar
washers, metal
water bottle, animal
waxed paper
weights, std. set metric
wire, bare copper 22 GA, 125 GA
wire cutter, stripper
wire, insulated copper 22 GA
wood splint

A Lab Inventory Self-Test follows. The purpose of this test is to allow the reader to identify deficiencies in lab equipment and materials knowledge. Take the test and see where you need more experience.

LAB INVENTORY SELF-TEST

1. A trowel is used to:
   ___a. induce current flow
   ___b. measure protein
   ___c. balance weights
   ___d. measure volume
   ___e. dig soil

2. Daphnia
   ___a. live only in salt water
   ___b. are found at the top of a food pyramid
   ___c. live only in fresh water
   ___d. are able to manufacture their own food
   ___e. reproduce by fission

3. Which of the following is the usual laboratory container for culturing mold?
   ___a. beaker
   ___b. graduated cylinder
   ___c. test tube
   ___d. petri dish
   ___e. flask

4. Which of the following would be the best medium for raising bean plants?
   ___a. sand
   ___b. clay
   ___c. gravel
   ___d. loam
   ___e. styrofoam

5. Which of the following classroom organisms would live best on a diet high in bran?
   ___a. hamsteres
   ___b. goldfish
   ___c. earthworms
   ___d. daphnia
   ___e. mealworms

6. Which of the following is most frequently associated with petri dishes?
   ___a. test tube rack
   ___b. tongs
   ___c. nutrient agar
   ___d. alligator clips
   ___e. hot plate

7. Which of the following is not recommended as classroom animals for health reasons?
   ___a. turtles
   ___b. gerbils
   ___c. mice
   ___d. goldfish
   ___e. ants

8. What chemical would be used to stain onion cells for microscopic observation?
   ___a. lemon juice
   ___b. baking soda
   ___c. vinegar
   ___d. iodine
   ___e. food color

9. Which set of materials would you use to investigate phototropisms?
___a. paper cup, soil, bean seeds, box, scissors
___b. binoculars, trees
___c. telescope, stars
___d. microscope, microscope slide, cover slip, onion cells
___e. none of the above

10. Which set of materials would be most useful in demonstrating germination?
___a. microscope, camera, seeds
___b. baggie, paper towel, water, seeds
___c. petri dish, agar, seeds
___d. microscope, scissors, seeds
___e. baggie, potatoe, water

11. Mealworms are:
___a. immature moths
___b. larva of a spider
___c. parasites found in grain
___d. adult worms that live in cereal
___e. larva of an insect

12. Which of the following would you use to measure liquid precipitation?
___a. ruler
___b. psychrometer
___c. hydrometer
___d. hygrometer
___e. rain gauge

13. In geology, a streak plate is used to:
___a. track meteors
___b. press plants
___c. etch glass
___d. classify rocks
___e. identify minerals

14. Marble or limestone chips:
___a. turn blue when iodine is placed on them
___b. bubble when hydrochloric acid is placed on them
___c. react violently when ammonia is placed on them
___d. are chemically inert
___e. dissolve rapidly in water

15. Which instrument is used to measure air pressure?
___a. barometer
___b. hygrometer
___c. anemometer
___d. thermometer
___e. hydrometer

16. Identify the situation that would pose the greatest safety hazard to students.
___a. viewing a lunar eclipse with the naked eye
___b. viewing the moon with binoculars
___c. looking directing at the sun
___d. watching a lunar eclipse
___e. standing in a meteor shower

17. Which set of apparatus and materials would be most useful to measure the volume of an irregularly shaped solid?
___a. graduated cylinder, water
___b. metric tape
___c. metric tape, spring balance
___d. metric tape, balance, set of weights
___e. tin can, water, metric tape

18. A spring scale could be used to measure:

___a. area
___b. weight
___c. volume
___d. density
___e. distance

19. Bar magents and horseshoe magnets differ in that:

___a. the poles were reversed
___b. they are a different shape
___c. they are made of different material
___d. bar magnets are stronger
___e. horseshoe magnets are stronger

20. Which metric unit of measurement listed below indicates length?

___a. kilometer
___b. liter
___c. kilogram
___d. joole
___e. decible

21. Which metric unit of measurement listed below indicates volume?

___a. kilometer
___b. liter
___c. kilogram
___d. joole
___e. decible

22. Which metric unit of measurement listed below indicates weight?

___a. kilometer
___b. liter
___c. kilogram
___d. joole
___e. decible

23. Which of the following would not be used in the process of making a pipette?

___a. graduated cylinder
___b. glass tubing
___c. safety goggles
___d. triangular file
___e. burner

24. Identify the instrument you would use to determine the density of a liquid.

___a. anemometer
___b. hygrometer
___c. barometer
___d. hydrometer
___e. none of the above

25. Bar magnets should be stored:

___a. on top of each other with poles together
___b. on top of each other with opposite poles together
___c. in a straight line with like poles together
___d. in a straight line with unlike poles together
___e. in a metal box

26. Identify the device that can be made with a battery, a piece of wire, and a nail.

___a. a thermostat
___b. an electromagnet
___c. a bimetal rod
___d. a buzzer
___e. a could chamber

27. A bimetallic strip is used to demonstrate:

___a. expansion and contraction
___b. parallax and distance
___c. hardness and softness
___d. refraction and reflection
___e. none of the above

28. Identify the item that does not belong in this grouping.
___a. buzzer
___b. alligator clips
___c. knife switch
___d. bimetal rod
___e. insulated wire

29. A convection box is used to show:
___a. air currents
___b. liquid density
___c. light refraction
___d. spectrium color
___e. none of the above

30. What apparatus best demonstrates refraction?
___a. mirror
___b. telescope
___c. rubber ball
___d. glass of water and pencil
___e. none of the above

31. The greenhouse effect is best demonstrated with:
___a. an automobile
___b. a balloon
___c. a prism
___d. a north facing room
___e. a bell jar and vacuum pump

32. What apparatus would best demonstrate how the screw is related to an inclined plane?
___a. a pully
___b. pencil and triangular piece of paper
___c. a wheel and axle
___d. screw driver
___e. none of the above

33. Which of the following would be used to oxygenate water?
___a. willow tree
___b. elodea
___c. decaying plants
___d. plastic plant
___e. salt

34. Bromthymol blue is a:
___a. strong acid
___b. growth regulator
___c. chemical timer
___d. indicator solution
___e. food additive

35. What chemical would you use to test for starch?
___a. sodium chloride
___b. hydrogen peroxide
___c. iodine
___d. chlorine
___e. limewater

36. Which of the following would you use to test for carbon dioxide?
___a. limewater
___b. iodine
___c. chlorine
___d. hydrogen peroxide
___e. litmus paper

37. What would you use to separate sugar from a water solution?
___a. magnet
___b. filter paper
___c. ph paper
___d. dish in the sun
___e. electroscope

38. What device is often associated with the term spectrum?
___a. telescope
___b. convex lens
___c. concave lens
___d. mirror
___e. prism

39. Lugol's solution contains:
___a. iodine
___b. epsom salts
___c. calcium hydroxide
___d. bromthymol blue
___e. sugar

40. A dropper pipette would:
___a. be appropriate to use in kindergarten
___b. be too expensive for common use
___c. be hard to store
___d. have a short shelf life
___e. be illegal in most states.

41. The safest materials for a volcano model are:
___a. ammonium dichromate and water
___b. vinegar and baking soda
___c. aluminum sulfate and water
___d. limestone and hydrochloric acid
___e. lava

42. Given five labeled cups containing vinegar, lemon juice, ammonia, baking soda solution, and tap water, which of the things listed below would best identify which chemicals are acids and which are bases?
___a. red and blue litmus paper
___b. blue litmus paper
___c. limewater
___d. iodine
___e. filter paper

43. Given the following apparatus: wide-mouthed bottle, 2-hole rubber stopper, rubber tubing, 2 small glass tubes, jar, limewater, baking power, vinegar, safety goggles. What gas would an experiment using these apparatus test for?
___a. carbon dioxide
___b. oxygen
___c. methane
___d. nitrogen
___e. ozone

44. Which instrument would you use to measure heat?
___a. graduated cylinder
___b. humidity table
___c. bimetal rod
___d. thermometer
___e. calorimeter

Key to Lab Inventory Self-Test

1. e
2. c
3. d
4. d
5. e
6. c
7. a
8. d
9. a
10.b
11.e
12.e
13. e
14. b
15. a
16. c
17. a
18. b
19. b
20. a
21. b
22. c
23. a
24. b
25. b
26. b
27. a
28. d
29. a
30. d
31. a
32. b
33. b
34. d
35. c
36. a
37. d
38. e
39. a
40. a
41. b
42. a
43. a
44. e

Do you need to discuss your results with the instructor? You should have at least 80% correct.

Safety Factors (Component 6.4)

This section is organized to use the reference Science School Safety, (1984).

In our society today, we see the rising tendency to sue individuals in court. As a science lab instructor, you will be in an environment where this may occur. In order to protect yourself and the student, there are three duties for which you are accountable.

1.Duty to instruct students about lab safety.
2.Duty to supervise while students are in the science lab.
3.Duty to maintain a safe laboratory environment.

As you address these following questions, you will become familiar with precautions and possible dangers associated with science labs. You may use past experiences or just plain common sense to answer the questions. If you need additional information, turn to the page in Science School Safety as indicated at the end of each question.

Give an example of a specific danger that may exist with each of the following items:

1. Sound-producing instruments (p. 80)
2. The uses of heat in the laboratory (p. 82)
3. Sources of bright light (p. 84)
4. Electricity or magnets (p. 85)
5. Flying objects (p. 87)
6. Acids and basis (p. 92)
7. Flammable liquids (p. 93)
8. Wild animals (p. 58)
9. Plants (p. 61-64)

Identify a specific precaution to be used when:

1. studying geology (p. 88)
2. studying astronomy (p. 89)
3. studying the weather (p. 90)
4. using chemicals (p. 91)
5. using toxic substances (p. 94)
6. household pets are brought to class (p. 58)
7. dissecting (p. 60)
8. studying actual plants (p. 61-64)
9. studying microorganisms (p. 65)
10. using machines (p. 83)

There are special safety concerns associated with field trips and the use of computers. Be familiar with these aspects. Pages 68-72, 105-107.

After studying pages 37-51, design a safe science laboratory (There is no one correct way.) Include in your drawing the following items:

a storage and display area
waste disposal equipment
liquid spill equipment
storage site for gloves, sharp tools and fire blanket
location of fire alarm and fire extinguisher
safety rule sign
and any other items you wish to include

BE SURE TO LABEL THE ITEMS.

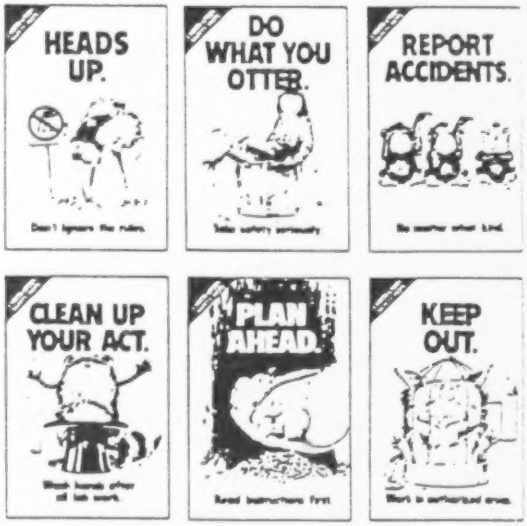
REFERENCES

Gerlovich, Jack A. et. al. School Science Safety, Elementary. Flinn Scientific Inc. Batatia, Illinois, 1984.

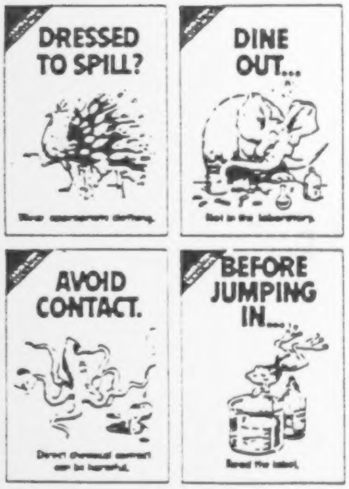
MAKE SAFETY A VISIBLE CONCERN.

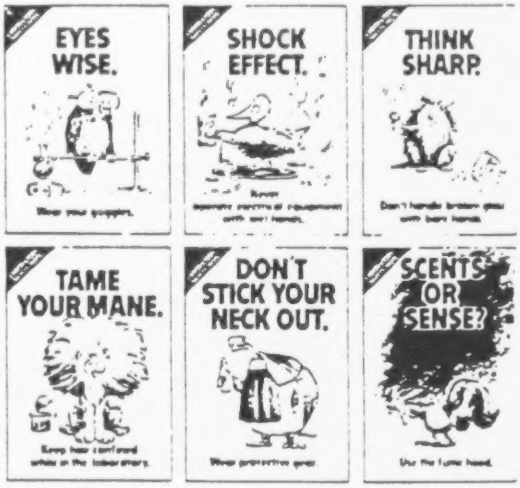
These large and colorful posters (we call them "Safety Notes") keep student attention on laboratory safety. They help you develop safety attitudes, safety awareness and safety concepts through constant reinforcement and a unique presentation. "Safety Notes" are always at work promoting lab safety whenever they are displayed. "Safety Notes" or posters assist science teachers in their responsibility for a safer setting.

Laboratory Safety Notes are printed in two colors on heavy gloss stock, 12 x 18".


HEADS UP.
DO WHAT YOU OTTER.
REPORT ACCIDENTS.
CLEAN UP YOUR ACT.
PLAN AHEAD.
KEEP OUT.

SET A (Pictured above)
Catalog No. AP4244 . . . . Set of 6 $20.95


DRESSED TO SPILL?
DINE OUT...
GET THE SEAL OF APPROVAL.
AVOID CONTACT.
BEFORE JUMPING IN...
A PLACE FOR EVERYTHING.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THINK SHARP.
TAME YOUR MANE.
DON'T STICK YOUR NECK OUT.
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2 Sets . . . . . . if yes, your price is $18.85 per set
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Chapter 10
CURRICULUM MATERIALS

The intent of this chapter is to expose the student to a sampling of elementary science curricula that are currently available for classroom use. It must be recognized that it is not possible to have an in-depth exposure to all that is available, nor would it be desirable.

Industry and Non-Profit Organization Curricula (Component 7.1)

Many exemplary materials are available from non-profit and industry sources. These materials are often provided at no or little cost. Users should be aware that the materials are not of equal value. Many are clearly propaganda and some contain poor science. An example is People and Animals (1981). This curriculum contains numerous lessons where students are asked to make non-scientific inferences based upon anthropomorphic viewpoints (p. 74, Level K; P. 69, Level 6).

At the primary level, children's stories are full of anthropomorphisms. Often these stories give the animals human characteristics. Other stories personify inanimate objects. One of my favorites is "The Drop of Water That Wanted to Be Beautiful." It is a story about the water cycle. A drop of water starts in the sky with a dirty middle (condensation nucleus). Ask any second grade child how such a drop would feel under such conditions and the answer is always the same; "sad, " " unhappy." Ask them to make a drawing of the drop and it always has a sad face. Condensation, evaporation, and precipitation are all a part of the story. Do raindrops dive out of a cloud? No, the cause-effect relationship does not involve intelligent action on the part of the raindrop.

What harm is there in presenting such stories in the elementary grades? The argument for and against anthropomorphism has previously graced the pages of Science and Children (Hughes, 1973; Sharefkin and Ruchlis, 1974; Gallant, 1981). It has been pointed out that nursery rhymes, Disney animal films, and mass media presentations condition the participant so that critical sorting of real and imagined no longer occurs. The fantasies portrayed begin to be viewed as reality, as truth.

In the drop of water story, children are asked if they have ever dreamed they were falling. Those that have are asked to describe the feeling. This feeling is then related to the falling drop of water. The dirty middle, sensation of falling, and landing in oil all contribute to an imagined feeling of ugliness. This gives the water cycle color and children enjoy learning about it. The important vocabulary condensation, evaporation, and precipitation is retained by the child. No harm done!

But what is truth? Truth is evidence of things as they are now, as they were in the past, or as they may be in the future. In science, our evidence is basically sensory. We all know that the drop of water does not have human characteristics, but when the senses are continually bombarded with imaginary images, reality can become distorted.

Observation and description of the natural world can be very dull. Inference gives more glamour to our observations. It is quite normal to infer in anthropomorphic terms. Observing and describing the palm of my hand might not be very interesting, but making inferences about me based on observations and your past experiences might be interesting. The inferences you make would be weaker truths than the observations; however, you could correct your errors by talking to me.

Anthropomorphism is erroneous inference. It is going beyond good evidence and presumes an erroneous cause and/or effect. The extrapolations on the part of an author are imagined and are not based on observations. The student may interpret anthropomorphisms as real rather than imagined. Thus, an author may use anthropomorphism for propaganda purposes.

Suppose an author wished to convince students that chickens should not be raised in confinement. By confining a number of students to an appliance box, study carrel, or under a desk, it is easy to illustrate boredom, nervousness, physical discomfort and general stress. Discussion leads to a conclusion that such conditions are undesirable. Then present the fact that egg-laying hens are generally kept in stacked 12" x 16" cages, four birds to a cage. A chicken's wingspread is 32 inches. Ask: Do chickens also experience stress when they are confined in small cages? The student that has been conditioned to think in anthropomorphic terms will infer that chickens react to such an environment in the same way humans do.

The above strategy is a part of what is called humane education. In the introduction to People and Animals, it is pointed out that "humane education involves far more than the teaching of simple animal-related content." The chicken activity above is one of many in this curriculum that are designed "to help students think critically and clarify their own feelings about various issues, as well as to provide them with factual information about animals." The danger in this approach is that there is enough fact blended with anthropomorphic propaganda so that the student is programmed to arrive at curriculum-determined value.

The People and Animals materials also take similar approaches to the concept of harvestable surplus. By inference, hunted animals are given human characteristics. The anti-hunting ethic comes through loud and clear based on anthropomorphic inference rather than sound science.

The curriculum also relates behavior of animals in zoos to people confined to a bedroom. Students are guided to infer that animals in captivity would react in a manner similar to that of people being observed in a bedroom. It is easy to conclude that animals would be more comfortable in the wild; except that the curriculum does not promote investigation of the wild.

It is evident that such curricula instill a value into the children rather than helping them clarify values. The goal is a philosophy that animals should be provided the same moral protections that govern our behavior toward one another. The general line of inference is that if we are animals, then animals have rights like humans. The error is in giving the animals human characteristics.

If we (all animals) are equal, then there is no other alternative but vegetarianism. But then, maybe that drop of water also has human characteristics, so now what shall I drink!

Project Wild (1983), another non-profit organization produced set of materials, has some similar activities. "How Many Bears Can Live in This Forest" (p. 115) is a fun activity, but it gives bears human attributes that do not exist in nature. The lesson objectives are achieved, but the conclusions are based upon anthropomorphic inferences.

Project Learning Tree (1987) is probably the best example of multidisciplinary approach, industry produced elementary science materials. The American Forest Council sponsored these teacher-written materials. They are free of bias and very motivating.

Locally, Water Education, Grades K-6 (Daugs & Israelsen, 1985) also fits into the category of non-profit organization-produced materials. They are scientifically correct and integrate science with other parts of the curriculum. The National Energy Foundation and the Utah Ag in the Classroom program have also provided materials for science classrooms.

Assignment

Use the outline that follows to examine two industry or non-profit organization-produced sets of materials.

Rating Scale

0 - Book totally lacking in the characteristic
1 - Occasional evidence of the characteristic
2 - Evidence of the characteristic but below average
3 - Frequent evidence of the characteristic
4 - Excellent evidence of the characteristic
5 - Superior in all aspects of the characteristic

DEVELOPMENT	Series A	Series B	Series C
Authorship includes professional science writers for children.			
Authorship includes experts in the field of science education.			
Authorship includes specialists in the science disciplines (Physical, Life and Earth Science).			
Materials were field tested in a variety of classroom settings.			
PROGRAM			
Program is adaptable to more than one instructional method (traditional textbook approach/inquiry methods).			
Program content emphasizes life science with a practical balance between physical and earth science.			
Content organization is consistent from grade level to grade level.			
Content is interesting and manageable for the intended grade level.			
Experiments are included in every unit of the program.			
Experiments encourage both quantitative (How long? How much? How fast? Compare) and qualitative (What color? What kind?) observations.			
Experiments call for the formulation of hypotheses, predictions, inferences and explanations.			
Experiments call for the collection and organization of data.			
Experimental situation provides opportunities for sharing and discussing data.			
Experiments are conducted with readily available materials.			
TEACHER'S EDITION			
Teacher's Edition presents an overview of each level.			
Teacher's Edition presents an overview of each unit.			
Teacher's Edition provides a consistent lesson plan.			
Teacher's Edition provides for special needs youngsters. (Visually Impaired, Hearing Impaired, Slow Learner, Learning Disabled.)			
Teacher's Edition provides background material for the teacher on the page where it is needed.			
Teacher's Edition includes titles and summaries of additional reference books and films correlated to unit themes.			
Learning Outcomes are stated in measurable terms.			
References to workbooks are indicated.			
Answers to review questions are provided on the page where they occur.			
Teacher's Edition includes the means and method of evaluation.			
Teacher's Edition shows how science instruction can be correlated to other curriculum areas.			

SUPPLEMENTARY MATERIALS	Series A	Series B	Series C
Workbooks are full-color, lively activities that reinforce and extend unit concepts.			
Workbooks include vocabulary review.			
Workbooks are referenced to textbook lesson.			
Criterion-referenced tests are available on spirit duplicating masters.			
GENERAL FEATURES			
Readability of the program is reported in specific scores for each level and each unit within the level.			
Vocabulary aids include context definitions, pronunciation guides, marginal definitions, and glossary definitions for all new science terminology.			
Glossaries on the primary levels are illustrated.			
Glossaries include page references to where the word was introduced and reused.			
Body of the text includes both English and Metric units of measure.			
Appendix of Metric and English units of measure is included.			
Graphics include photographs, illustrations, and scientific line illustrations.			
Graphics attract attention and generate discussion.			
Graphics deliver information and contribute to the instructional program.			
Book covers are attractive, substantial, and durable.			
Program includes provisions for updating the content with recent science developments.			
TOTAL			

Additional Information on Anthropomorphism (Component 7.1)

"Pitfalls of Personification"

by Roy A. Gallant

From the time we are very young we are read nursery tales about bears that dance and eat porridge, rabbits that wear trousers, and other animals that respond to each other as if they were human. As we grow older, these early childhood lessons in animal behavior are reinforced by the bad biology so common in popular literature and films, such as Disney animal extravaganzas. By our teens, we have been exposed for so long to a world of humanized animals, talking automobiles, singing pills, "bad" wolves, and "gentle" bears that we are conditioned and take little critical notice of the myriad gross distortions of the natural world that bombard us through the mass media. The problem is compounded when teachers inadvertently reinforce and perpetuate mass media myths about animal behavior.

Of course, one can argue that everyone knows automobiles don't talk (at least Detroit hasn't produced one yet!), bears seldom eat porridge, and cuddly animals don't wear clothes, at least outside the nursery. As adults, we are better able to detect fantasy and selectively dismiss it as a real ingredient of an animal's behavior repertoire.

The difficulty comes when a deliberate or inadvertent distortion of animal behavior comes so close to reality that untrained observers cannot distinguish fact from fiction. If that were not so, there would be fewer tourists in our national parks mauled by the "friendly" bears, despite park rangers' warnings that the bears are wild. There also would be fewer young people's animal books that are mines of misinformation, too often dismissed as harmless because they are intended as "entertainment" rather than education. There is, of course, no such sharp boundary separating the two. An imaginative teacher can use such books constructively to alert students to the pitfalls of personification.

Personification is the act of attributing life to nonliving things. In a tighter context, it is the act of attributing human emotions to nonhuman animals. There are three major types of personification.

Animism is personification in the broad sense. Despite its potential energy, a precariously balanced boulder cannot "want" to tumble over a cliff's edge any more than the air in a tire can "try" to get out, or the moon can "try" to escape Earth's gravitation. Such whimsies represent an easy way out of difficult explanations of physical forces—the air pressure in a tire, for example, or the acceleration of gravity in the moon-Earth system.

Anthropomorphism, the attribution of human characteristics to nonhuman organisms, is especially germane in the science classroom. In the film "Bambi", a story about a family of deer, the viewer is encouraged to condemn Bambi's father because he "deserts" Bambi's mother. "Desertion" connotes the violation of a social value held by humans only. Can any predator other than man be "evil?" Is a kitty cat any more "ruthless" in killing a sparrow than in killing a rat? Attributing human emotions to nonhumans is a sure way of misunderstanding why an animal behaves the way it does. Contrary to many children's books, birds do not sing on clear spring mornings because they are happy. Bird song serves quite different functions. It is the male's way of marking and defending a territory, a means of identifying conspecifics, or, in some cases, of identifying familiar individual birds.

Warm, intrude, anger, desire, loyalty, and other such words describe human actions and emotions. Sometimes we are tempted to use them indiscriminately when we see an animal behaving in such a way that we are involved emotionally. When a dog growls and lays back its ears, we say the animal is "angry." Is it? Can a dog feel anger as we do? The animal is displaying aggressive behavior, but anger is something else.

The central problem—and this applies particularly to anthropomorphism—is semantic. Animal cries, growls, grunts, and whimpers mean something to other animals, and sometimes to us, but a growl is only a sign, not a word. A wolf's growl lacks the precision and richness of the word growl, although as a graded signal, the sound has a range of meanings to a wolf. By our standards, animal communication is severely limited; what is important for the animal is that it is able to communicate well enough to survive—to defend itself, court mates, and care for its young.

Teleology leads to as much misunderstanding as anthropomorphism does. It means attributing purpose to an animal's act. By doing so, we give the impression that animals think through threats to their survival and arrive at rational solutions. Not so.

Here is the sort of teleological statement that pervades textbooks and children's trade books: "Certain animals migrate in winter to avoid the harsh conditions." The author implies that each animal of the species in question works it all out and decides it had better find a warmer spot for the winter. Animals do not migrate in order to survive any more than they mate in order to produce young. They migrate because their internal environment responds to external stimuli ("photoperiod", for example). They migrate with the result that they avoid harsh seasonal conditions and, therefore, survive.

Similarly, animals do not court and mate because they "want" offspring, but because of genetic pressure. They repond to internal and external environmental stimuli, as their ancestors have for generations. There can be no such thing as family planning among cockroaches.

Hibernation is an adaptation that enables certain species to survive temporarily harsh conditions. Animals do not decide to grow thick winter coats or change the color of their fur. To presume that a rabbit willfully grows a winter coat of white is to presume that animals assess each change in the environment, then select the best response. Animals simply reflect evolutionary adaptations. If we label certain animals "good" and others "bad", we can never understand food webs or, on a grander scale, the marvelously complex interactions between animals and their environment.

Young science students must try to see the natural world from the view of the nonhuman animal. Until they are made aware of the pitfalls of personification, they stand little chance of understanding why a bird, an ant, or a dog behaves the way it does.

"Anthropomorphism in the Lower Grades"

by Belle D. Sharefkin and Hy Ruchlis

In the article, "Anthropomorphism, Teleology, Animism, and Personification--Why They Should Be Avoided," in the April 1973 issue of S & C, Austin Hughes makes the familiar plea that teachers in the lower grades and writers of science books for young children should avoid describing animals by means of characteristics used in describing human behavior. Such anthropomorphic descriptions, it is argued, produce basic misconceptions that make it more difficult for teachers at upper levels to build on the conceptual foundation laid down in the lower grades.

We believe that the kind of prohibition against anthropomorphic formulation desired by Hughes and others who express his point of view is too sweeping in scope and needs to be limited in the light of recent findings about the psychology of young children.

Historically, it was essential for Darwinists of the late Nineteenth Century to launch a concerted attack on the ingrained anthropomorphism and personification which were a heavy part of pre-Darwinian thinking. That struggle must still continue at advanced levels of science education, but recent evidence reveals that there is a conceptual level for young children below which it is irrelevant, and perhaps counterproductive, to require that they express themselves in the anti-anthropomorphic terms expected at more advanced levels. It may also be counterproductive to require teachers of young children and writers of books for this audience to avoid any hint of anthropomorphism and personification in their attempts to communicate ideas.

Jean Piaget has shown that cognitive development of children passes through well-defined stages. The sensorimotor stage ranges from birth to approximately 18 months of age, the preoperational from approximately 18 months through 7 years, the concrete operational from approximately 7 through 11 years and the formal operational stage (the adult, logical way of thinking) from approximately 11-12 years through 14-15 years. (There should be emphasis on approximately.)

Children in the lower primary grades are generally at the preoperational or concrete operational stage of thinking. The preoperational is characterized by a high degree of egocentrism, personalization, and nonabstract thinking. For these children, anthropomorphic formulations are not only natural, but actually aid comprehension of the world they observe. Even at the concrete operational stage, the child's ability to deal with elementary groupings of classes and relations, so essential to logical thought, depends largely on interaction of sense perceptions with objects or phenomena. He proceeds from one step to another without necessarily linking or relating variables because he does not tend to act on verbally expressed hypotheses. Consequently, when a child encounters a concept expressed in language, to comprehend it, he requires that it be related to the body of concepts and feelings that are a part of his thinking, and these are often related to anthropomorphism and personification.

One of Piaget's main findings is that the early stages of cognitive development depends on interaction with objects, animals, and people, especially one's peers. Experienced teachers have long known that children can readily relate to real or imagined feelings in animals and objects, whereas they generally have great difficulty in relating to or comprehending feelings outside their realm of experience. Possibly young children will more readily learn about animals, or plants, or even about some properties of objects through personification and anthropomorphism. If this thesis is not a fact, let it at least be given the status of a reasonalbe hypothesis, on an equivalent level with the generally accepted hypothesis that anthropomorphism is verboten.

To illustrate the difficulties we encounter with absolute prohibitions against anthropomorphism, consider the situation of a dog who greets his young friend by running forward, vigorously wagging its tail and jumping up to kiss his friend's face. Not only the young child, but the average adult as well, will describe this behavior by saying that the dog is "happy" to see his friend. But this is an anthropomorphic formulation which sees the dog's behavior in human terms. After all, nobody ever talked to a dog to find out if he really is happy in the same sense as a human being, or even to find out if dogs have their own ideas of happiness.

The difficulty with prohibiting such an anthropomorphic formulation is that we are then hard put to describe the dog's behavior in any other simple way. If the child (or adult) says that the dog is "happy", shall we correct him by saying something like: "No. The dog is not really happy. He is just responding in his characteristic doggy manner to seeing, once again, a familiar person with whom he has had pleasant associations in the past." How would writers or teachers who hope to be effective in communicating with children avoid the "natural" anthropomorphic formulation?

We think we know how others feel when they are happy because they act in the same manner as we do when we are happy. The dog sees a good friend and greets him as we do. The dog may do it differently, with less reserve and with appropriate use of specialized boy parts. Obviously, the dog can't shake hands, or throw its arms around the friend. So the animal does the best it can with typical doggy limitations (and advantages) to communicate what seems to us like real pleasure in seeing a friend. Since this behavior has so many basic elements that are similar to the kind of pleasure we feel when we see a good friend there is certainly good reason for the child or adult—and perhaps even the scientist—to describe it with a reasonably available word: happy.

The word "happy" is derived from observing human behavior, but there is no equivalent word for similar behavior observed in animals. Should we forbid the use of the word "happy" to describe animal behavior? Must we then go through the whole recitation of characteristics each time we want to talk about it, which children (and many adults) will not understand?

It is true that the word "happy" does not tell the whole story. What word does? Perhaps we could invent a new word as the equivalent of "happy behavior in animals." According to Piaget, however, such language would be an artificial accommodation for the child who has not yet developed the logical structure to enable him to assimilate this information. When a young person matures to the formal operational level, a teacher can extend the conceptual understanding of animal behavior and find more specific ways to describe it. But teachers of younger children should avoid too-rigid, exact formulations for which the child is not conceptually ready. Calling attention to characteristics of living things that seem to be related to human feelings—using anthropomorhic formulations—may well motivate and stir interest in (rather than detract from) later study of animals and their modes of behavior.

It is probably more useful for the teacher to be attuned to the child's individual cognitive level as manifested by his comments and respones than to be overly concerned with the precise scientific formulation. With good teaching that is sensitive as well as sound, no dichotomy needs to exist.

We make no plea to justify incorrect teaching. All we are saying is that common sense and educational psychology should play a role in determining how we formulate concepts for young children. There are times and circumstances when anthropomorphism will do no harm and may possibly do some good. What the anti-anthropomorphists should address themselves to are the circumstances under which anthropomorphic formulations are desirable, tolerated, or prohibited. Basically, it is a problem of communication between disciplines. Teachers will have to listen to criticisms by biologists, but the biologists are going to have to listen to teachers, too, and take into account basic educational psychology which they may often forget.

Anthropomorphic descriptions are sometimes used by well-known scientists. Richard Feynman, Nobel laureate in physics, describes how he learned about science as a child in the following words:

> Incidentally, in the forest we learned other things. We would go for walks and see all the regular things, and talk about many things; about the growing plants, the struggle of the trees for light, how they try to get as high as they can, and to solve the problem of getting water higher than 35 or 40 feet, the little plants on the ground that look for the little bits of light that come through, all that growth, and so forth.

Note the anthropomorphic use of such terms as "the struggle of the trees for light," "try to get as high as they can," "solve the problem of getting water," and "look for little bits of light." (And these are not even animals.)

Darwin's study of the "Expression of Emotions in Men and Animals" uses such titles for sections as Affection, Joy, Contentment, Pain, Anger, Anxiety and Depression, Astonishment, Terror, etc. Ethological studies sometimes use expressions for characteristics of human behavior in their study of animals.

A considerable portion of Austin Hughes' article is devoted to discussion of inappropriate attributions of "purpose" in relation to animals. But what shall we say about a certain Irish Setter who, when his friend's car passed by, would always dash across the adjoining field, on a diagonal path, not following the car at all. Subsequently, he would arrive at the friend's house vigorously wagging his tail, waiting for the car to round the bend. Can we really say that the dog did not have any purpose or intention in this obviously intelligent behavior? The fact that the dog always dashed across the field instead of following the car and always came out ahead because of his action would seem to be some kind of evidence of purpose and intention. The blanket denial of purpose for animals may not be an inflexible absolute.

Mr. Hughes has a stronger argument when he comes to evolutionary considerations. He cites this example: "A hummingbird has a long bill so that it can reach into flowers and suck out nectar." He suggests intead the formulation, "The hummingbird uses its long bill to reach into flowers to feed on nectar." He objects to the first formulation because it may be interpreted to ascribe purpose to the process of acquiring the long beak. But does this really matter very much at an age level where the distinction is lost on the child whose correct interpretation of "adaptation" will only be learned at a much later age through his restructuring of perceptions, observations, and conceptions?

There is again a partly semantic problem in the interpretation of the phrase "so that." To a young child, the phrase "so that" may mean "enabling," "making it possible for" or "helping him to." For older children, Hughes may have a point; it may imply "purpose." There is also a change from "suck out" to "feed on," which may have the effect of only making it dull, rather than correcting a misinterpretation.

We are dealing here with complex questions in which biology, semantics, psychology of child develpment, and pedagogy are all closely intertwined. Simply prohibiting anthropomorphism from any teaching is an easy way out of the problem. Certainly, we need more discussion of formulation of concepts so that teachers may become expert in reconciling the needs of subject matter in the light of what we know about child development and the usage of words. Faced with this difficult, but not insurmountable, problem, teachers who are trying to do their best need not feel paralyzed with guilt about errors they may commit; but rather may gain assurance in the knowledge that this is a two-way street and that the critics may be making errors too, at their end of it. Neither is entirely right or wrong, but both are essential. What good is a complicated, albeit correct, scientific statement if it turns a young student completely off to science forever?

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Publisher-Produced Curricula (Component 7.2)

During the 1970's, the major emphasis was on second generation science curricula such as SCIS, SAPA, and ESS. These programs have now largely disappeared from the classroom. However, the ever-present first generation textbook is still the number one science curriculum resource in the elementary classrooms.

Because of the way texts can be used as a reader, their use has generally received a bad review. However, modern textbooks can be much more than a reader. All contain great pictures, most have good demonstrations and lab activities. Some contain creative science extensions. Nearly all textbooks tend to be very traditional in format and content.

Assignment

Use the form that follows to evaluate one or more publisher produced elementary curricula. Examine only one grade level of a series.

Rating Scale

0 - Book totally lacking in the characteristic
1 - Occasional evidence of the characteristic
2 - Evidence of the characteristic but below average
3 - Frequent evidence of the characteristic
4 - Excellent evidence of the characteristic
5 - Superior in all aspects of the characteristic

DEVELOPMENT	Series A	Series B	Series C
Authorship includes professional science writers for children			
Authorship includes experts in the field of science education			
Authorship includes specialists in the science disciplines (Physical, Life and Earth Science)			
Materials were field tested in a variety of classroom settings			
PROGRAM			
Program is adaptable to more than one instructional method (traditional textbook approach/inquiry methods)			
Program content emphasizes life science with a practical balance between physical and earth science			
Content organization is consistent from grade level to grade level			
Content is interesting and manageable for the intended grade level			
Experiments are included in every unit of the program			
Experiments encourage both quantitative (How long? How much? How fast? Compare) and qualitative (What color? What kind?) observation			
Experiments call for the formulation of hypotheses, predictions, inferences and explanations			
Experiments call for the collection and organization of data			
Experimental situation provides opportunities for sharing and discussing data			
Experiments are conducted with readily available materials			
TEACHER'S EDITION			
Teacher's Edition presents an overview of each level			
Teacher's Edition presents an overview of each unit			
Teacher's Edition provides a consistent lesson plan			
Teacher's Edition provides for special needs youngsters. (Visually Impaired, Hearing Impaired, Slow Learner, Learning Disabled.)			
Teacher's Edition provides background material for the teacher on the page where it is needed			
Teacher's Edition includes titles and summaries of additional reference books and films correlated to unit themes			
Learning Outcomes are stated in measurable terms			
References to workbooks are indicated.			
Answers to review questions are provided on the page where they occur			
Teacher's Edition includes the means and method of evaluation			
Teacher's Edition shows how science instruction can be correlated to other curriculum areas			

SUPPLEMENTARY MATERIALS	Series A	Series B	Series C
Workbooks are full-color, lively activities that reinforce and extend unit concepts			
Workbooks include vocabulary review			
Workbooks are referenced to textbook lesson			
Criterion-referenced tests are available on spirit duplicating masters			
GENERAL FEATURES			
Readability of the program is reported in specific scores for each level and each unit within the level			
Vocabulary aids include context definitions, pronunciation guides, marginal definitions, and glossary definitions for all new science terminology			
Glossaries on the primary levels are illustrated			
Glossaries include page references to where the word was introduced and reused			
Body of the text includes both English and Metric units of measure			
Appendix of Metric and English units of measure is included			
Graphics include photographs, illustrations, and scientific line illustrations			
Graphics attract attention and generate discussion			
Graphics deliver information and contribute to the instructional program			
Book covers are attractive, substantial, and durable			
Program includes provisions for updating the content with recent science developments			
TOTAL			

Supplementary Materials and Journals (Component 7.3)

Many excellent resources exist for elementary science. This section mentions only a few.

Every elementary science teacher should be familiar with Science and Children. This journal is published by the National Science Teachers Association. Every issue contains a wealth of interesting, practical activities. The National Science Teachers Association also publishes Science Scope, which contains similar materials for the middle school level.

Other good source of supplementary materials are Science Activities published by Heldref Publications, and Nature Scope published by the National Wildlife Federation.

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Chapter 11

PRACTICUM

Level III Practicum (Component 8.0)

The practicum for El Ed 401 is carried out as part of the Level III practicum in Edith Bowen Lab School. During this experience, you will have half days in an elementary classroom for an entire term. The experience will be structured so that you have mornings for half the term and afternoons for the other half. Somewhere during this time, you will be expected to teach science. Amount of time devoted to science will vary with the classroom to which you are assigned.

Your practicum grade will be a part of the total Level III practicum grade.

Chapter 12

CONVOCATION

What is a Convocation? (Component 9.0)

The convocation has evolved into a culminating experience where students have a chance to demonstrate mastery of some aspect of teaching science. Experiences vary from term to term. We have taken over elementary schools for science days, had weekend science retreats, and have had invention conventions.

The invention convention has been a very rewarding experience. It relates to the technology part of the STS component. The original idea for an invention convention came from Silver Burdett Science (Valentino, 1984).

The section that follows outlines in detail an invention convention as a type of convocation.

The Invention Convention (Component 9.0)

"Human Nature: The Contriving Mind"

by Brooke Hindle

What was the catalyst behind the remarkable outpouring of major inventions in early America? Is there something in our style of thinking that continues to spark this wealth of creativity? What accounts for the great outburst of major inventions in early America—breakthroughs such as the telegraph, the steamboat and the cotton gin?

Among the many shaping factors, I would single out the country's excellent elementary schools; a labor force that welcomed the new technology; the practice of giving premiums (cash incentives) to inventors; and above all the American genius for nonverbal, "spatial" thinking about things technological.

Why mention the elementary schools? Because thanks to these schools our early mechanics, especially in the New England and Middle Atlantic states, were generally literate and at home in arithmetic and in some aspects of geometry and trigonometry.

Acute foreign observers related American adaptiveness and inventiveness to this educational advantage. As a member of a British commission visiting here in 1853 reported, "Bringing a mind prepared by thorough school discipline...the American boy develops rapidly into the skilled artizan."

Not surprisingly, these "artizans" had a friendly outlook on the Industrial Revolution. A committee of Britain's Parliament was told, "In America...all the workmen in the establishment would...lend a helping hand (to develop a new machine)...But in England...If the workmen could do anything to make a machine go wrong, they would do it." Another visitor reported, "There is not a working boy of average ability...who has not an idea of some mechanical invention...by which he hopes to rise to fortune and social distinction."

A further stimulus to invention came from the "premium" system, which antedated our patent system and for years ran parallel with it. This approach, origniated abroad, offered inventors medals, cash prizes, and other incentives.

In the United States, multitudes of premiums for new devices were awarded at county fairs and at the industrial fairs in major cities. Americans flocked to these fairs to admire the new machines and thus to renew their faith in the beneficence of technological advance.

Given this optimistic approach to technological innovation, the American worker took readily to that special kind of nonverbal thinking required in mechanical technology. As Eugene Ferguson has pointed out, "A technologist thinks about (objects) that cannot be reduced to unambiguous verbal descriptions; they are dealt with in his mind by a visual, nonverbal process...The designer and the inventor...are able to assemble and manipulate in their minds devices that as yet do not exist."

This nonverbal "spatial" thinking can be just as creative as painting and writing. Robert Fulton once wrote, "The mechanic should sit down among levers, screws, wedges, wheels, etc. like a poet among the letters of the alphabet, considering them as an exhibition of his thoughts, in which a new arrangement transmits a new idea."

Such thought processes verge closely upon those evident in painting and sculpture, and it is no accident that so many of the early American inventors were also artists—among them Robert Fulton (the steamship), Samuel F. B. Morse (the telegraph), and Rufus Porter (founder of the Scientific American).

When all these shaping forces—schools, open attitudes, the premium system, a genius for spatial thinking—interacted with one another on the rich U. S. mainland, they produced that quintessentially American characteristic, emulation. Today that word connotes mere imitation. But in earlier times, it meant a friendly but competitve striving for fame and excellence.

Emulation, in this older, trurer sense, relied almost wholly upon spatial thinking; words and numbers were distinctly auxiliary. Because it focused on the best models of machines and on the men who made them—intead of focusing on the problems that were involved—it emphasized the positive (Hindle, 1983).

Fostering the development of important science skills is an ongoing task. Students should be given opportunities to solve problems, think creatively, experiment, and work with data throughout the school year. An invention convention is an event that gives students an opportunity to demonstrate these skills independently as they invent a new product or process.*

An invention convention can be a classroom, school, or districtwide science event. It is designed to encourage students to apply basic science skills in a creative and productive manner. Participants are encouraged to identify a need or to solve a problem by following the same steps and patent application procedures that an inventor would follow in patenting an invention. Once a need or a problem has been identified, students are directed to use problem-solving and creative-thinking skills to invent a product or process that would fill the need or overcome the problem. Communication and research skills are also greatly enhanced throughout the invention procedure.

Valentino (1984) suggests an invention convention involves five basic steps:

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* The materials that follow have been adapted from The Invention Convention, "Inventing with Children" and "The Inventive Thinking Project."

Step I Learning About Inventors:

In this step, students will learn about inventors and their inventions. The knowledge gained in this step will help students develop an appreciation for inventors and will help establish a positive attitude about the invention process. They will learn that successful inventors:

- keep an open and curious mind about the world around them.
- acquire as much information as possible about an idea, problem, or future invention before beginning to invent.
- constantly use trial and error as they engage in problem solving.
- constantly strive to improve upon an idea or design after finding a solution.
- are dedicated, persistent, and most of all, optimistic about finding a solution.

Once students have learned about inventors and inventions, you may wish to have each student write a brief tribute to an inventor.

Activity

Introducing Inventive Thinking

Introduce your children to inventive thinking by visiting the library to locate information about creativity, invention, and innovation.

- Read some stories about inventions and inventors.
- Invite a local inventor to speak to the class. Since local inventors are not usually listed in the phone book, you can find them by calling a local Patent Attorney or your local Patent Law Association. Your community may also have an Inventor's Society that you may contact. If not, most of your major companies have a Research and Development department made up of people who think inventively for a living.
- Next, look for the things in your classroom that are inventions. All the inventions in your classroom that have a United States Patent will have a patent number. One such item is probably the pencil sharpener.
- Other works that require inventive thinking are protected by law by Copyrights and Trademarks. Copyrights are usually found on written material such as your students' textbooks. The letter "c" and the date indicate a copyright. Look for copyrighted materials in your classroom. Trademarks are related to words, devices, names or symbols and are protected to indicate the source of certain goods and to prevent others from using a similar mark. A trademark is indicated by the letters "TM". One of the most famous trademarks is the Coca Cola label.

Step II Finding an Idea:

Finding a need to fulfill or a problem to solve is the second step in the invention process. The invention may be a new product or it may be a new process for doing something.

When asked to invent something, a person must use previous knowledge, skills, and experience. This information, along with new learnings must then be applied, synthesized, and evaluated. Through creative and critical thinking and problem-solving, ideas become a reality as children create an invention.

The following sections outline the techniques and definitions of terms vital to the teaching of creative thinking. These skills promote idea formation. The suggested classroom activities provide the students with a foundation for inventing.

Brainstorming

Brainstorming is a group method for generating a large base of ideas. A problem or topic is presented to a group. The group generates as many ideas as possible. One person records a list of the ideas generated.

Suggestions for Effective Brainstorming:

- List many ideas.
- Accept everything. Withhold any criticism or evaluation of the ideas generated; they can be refined later.
- Welcome the unusual or outlandish. Encourage the wild and different.
- Don't stop too soon. The greater the number of ideas generated, the more likely is the occurrence of the "creative".
- The teacher should also participate. The addition of your ideas to the pool can demonstrate divergence and add excitement to the process.
- Build and combine with ideas used in the past. Improve existing ideas or combine two or more ideas into a third idea (sometimes called piggybacking).

Activity

1. Consider how many people might enjoy eating ice cream as part of their lunch. Most of us use lunch boxes or paper bags for our lunches and cannot carry ice cream with us. Create an imaginative way to carry and maintain the solid condition of ice cream.
2. Explain your ideas to the group.
3. How did you react if your idea was encouraged?
   How did you react to any negative comments about your idea?
4. Think of all the things you can do to keep the idea alive in spite of the negative attitudes of yourself or others. Write them down on a piece of paper.
5. Do something to develop your idea!

Building Up Alternatives

This technique views things from a variety of perspectives, promoting the restructuring or rearrangement of information to create more ideas.

Use the following phrases to cue the students.
- "Think of different ways to..."
- List other possibilities for..."
- "What else might be considered...?"
- "How many different ways could you tell someone...?"
- "How many different uses can you think of for...?"

Activity

1. Look at the common iron and think about what it was originally designed to do. Consider the various ways the common iron is being used today. Since people are doing less ironing, what else are people doing with the iron?
2. What innovations have been made to the iron in recent years?
3. Take some time to ponder the probable future ways an iron might be used. Create mental images of using the iron in a variety of ways. Consider the iron from many points of view to enhance its possibilities. Jot some of your unique ideas on a piece of paper or draw pictures.

Attributing

Attributing is the process of looking into the characteristics of things. Information is gathered and ideas emerge as students apply attributes to new objects or situations.

Helpful Hints:

- List the properties or attributes of an object.
- List the object's physical characteristics.
- Ask the following questions:
  Of what other materials could it be made?
  What if it were a different size (larger or smaller)?
  What if it were a different color?
  What if you rearranged or reversed its parts?
  What if you added something?
  What if you eliminated something?
  What if you combined it with something else?
  What if it were shaped differently?
  What if it were longer, stronger, higher, thicker, lighter?
  What if it moved differently?
  What if it sounded differently?

Activity

1. Visualize a common plastic bottle. Try to picture its shape, color, texture, parts, and other characteristics.
2. Rapidly list as many attributes sa you can.
3. Picture the plastic bottle again. Turn it around in your mind and see it from many different viewpoints. Think of more attributes and add them to your list.
4. Think about the various materials you have seen inside a plastic bottle. Add these to your list of attributes.
5. Can you think of any other attributes connected with a plastic bottle? Add these characteristics to your list.
6. Now you have some concepts on which to create new ideas—perhaps a new product or process.

Associating

Associating means looking at the characteristics of an object and then viewing them from a different perspective, often through comparison or contrast. Help your students develop this skill by asking open-ended questions. Here are two examples:

- How is an (xx) (xx) like a (yy) (yy)?
- What is the same about (xx) (xx) and (yy) (yy)?

Remember, there is no one correct answer.

Activity

1. Suppose dishes were made of ice.
- How might your life change?
- In what possible new ways might you use them?
- What would be the advantages and disadvantages of dishes made of ice?
2. Suppose packages of frozen food could be opened with a zipper.
- How might the zipper improve the frozen food package?
- What might the zipper be like in order to fit on the package?
3. Suppose cans of soda could be opened from the side.
- How might this improve the soda can?
- How might you design a soda can that opens from the side and yet holds in the liquid?
4. Select the ideas you believe to be the most interesting and use them to create a new product or a new way of doing something.

Synthesizing

Synthesizing is a combining process; something is placed in combination with something else and a new entity is produced. The following are examples:

- What could you make more beautiful by making it wetter?
- What could you make more enjoyable by making it slower?
- What could you make more enjoyable by making it last longer?

Activity

1. Consider the idea of a book which has pages that slide in and out instead of the type that turn over.
2. On a piece of paper, list any reasons that kind of book might not be useful.
3. Review your list and eliminate the disadvantages by changing them into advantages. Think of ways each idea could be turned into a possibility.
4. List all the advantages that a book with pages that slide in and out might have.
5. Build on your list of advantages by creating a plan for a new kind of book based on your ideas.
6. List five or more "ridiculous" changes in a common object. Select one change and create ways it might be used. Take time to consider how this change might make the object better and how people might benefit from it. Develop a plan to demonstrate how the change you suggest might work.

Visualizing

Visualizing is using your imagination to see and fantasize in order to stimulate ideas. For example, consider the following:

- What if you were an appleseed inside an apple? Describe what you would see and hear.
- Pretend you could miniaturize yourself and enter a washing machine or a telephone. Describe your experiences and sensations.

Activity

1. Slowly visualize pictures of all the different kinds of plants you can recall. Keep the images drifting through your mind.
2. Now think of the names these plants have been given. Be sure to keep your mind sprouting with ideas.
3. On a blank piece of paper, sketch any plant (real or imaginary) that you would like to use to create "strange" ideas. You may wish to draw a plant showing the literal meaning of its name or a plant based on your visualization.
4. Look closely at your drawing and change the following things:

- Replace any leaves with objects used to aid or enhance your hearing.

- Replace the stem or trunk with any object used to clean things.
- Continue to substitute the various parts of your plant with tools or other objects of your choice.

5. You should now have an odd looking plant. Use a new piece of paper to redraw and refine your extraordinary plant.
6. Use your strange plant to trigger new ideas for an invention. Use more paper to plan your invention in detail.
7. When you are finished, discuss the following question with other students: How might our society encourage its people to use more imaginative thinking in dealing with problems?

The Part-Changing Method of Creative Problem Solving

One of the easiest way to create something new is to list an object's physical characteristics and then change at least one of them. Here are some easy exercises, appropriate for all ages.

1. Three qualities of a pencil are color, size, and shape. Invent some new kinds of pencils by listing 15 colors (for example, striped pencils like striped toothpaste), 5 sizes, and 10 shapes. Think of different or unusual ideas. Dont' worry about whether or not they are good.
2. Some noodles are shaped like tiny letter O's. Invent new noodles, thinking of some different shapes, flavors, colors, and sizes. These are four qualities of noodles which might be changed. Use your imagination. List your ideas.
3. Suppose you were a toy manufacturer with a warehouse of unsold frisbees. Change one or more parts or qualities of the frisbees. Make your frisbees different enough so that they will once again sell "like crazy" and make you a millionaire. Use the chart below to list the parts and qualities of the frisbees and then think of ways to change these parts. Be creative.

Part or Quality	**#1**	**#2**	**#3**	**#4**
Changes:				

4. What are some of the qualities of a doorbell, a laundry basket, a Band-Aid, a dandelion, a piece of sandpaper, an umbrella, a chalkboard eraser?
   List some changes and create something new.

Think Drawings

Think drawings provide a visual way to clarify ideas and inventive thoughts. Students develop ideas and then examine these ideas by drawing them.

Advantages of Think Drawings:

Age and ability range. Children from ages 5 to 15 and of widely varying abilities can create successful think drawings.
Sophisticated concepts. A child may express in a drawing sophisticated concepts difficult to express verbally.
Definite ideas. In a verbal description, a child might be vague but in a drawing, a child has to be exact.
Fantasy and fact. A child may apply known principles and fill in the other funtions with fantasy.
Ideas out in the open. A child may formulate thoughts in the open. A teacher can discuss the thoughts with the child, focusing on one feature after another. This process enables the child to design over and over again, altering and improving while developing new insights.
Speed. In a short amount of time, a child may draw a device which might take along time to construct (i.e., a spacecraft).

Guidelines for Think Drawings:

1. Subjects which solve a problem or "bring something about" are ideal for think drawings. Example: Design a better mousetrap.
2. Drawing as a "think medium" is quite distinct from "drawing as art." The quality of the drawing is not as important as the ideas expressed in it. Emphasize the function and action of the idea conveyed rather than the aesthetic appeal.
3. A child should draw thoughts, relationships, and funtions, rather than an accurate reproduction of some existing device. A think drawing must above all involve a child's thinking, not verbal memory or drafting techniques.
4. Encourage the use of color.
5. Encourage neatness and clarity, since it is difficult to understand a messy drawing.
6. Ask the younger child to explain the parts of his/her think drawing. A squiggle may have a significance not readily apparent from its shape.
7. The older child should label what is drawn and write notes explaining what happens in the drawing.
8. Discuss the various functions of the drawn invention. Encourage the student to draw what actually happens when the invention is used.
9. Stress the positive aspects of an idea. Also draw attention to omissions by asking questions ("What if...?").

Challenge Centers

Challenge causes many youngsters to feel uncomfortable. A child may recognize a need to meet a challenge but may not quite know how to do so. If a challenge is properly presented, however, a child will begin to investigate, ask questions, look at books, manipulate things, and guess at solutions. The following activities will help children learn to meet challenges comfortably.

Activities:

1. Develop challenging "what if" environments.
   - Create at least fifty colorful challenge cards that communicate a "bet-you-can't" invitation. Example: "Bet you can't make five new things out of a paper clip."
   - Students may choose any challenge they wish and, by using available materials, try to meet that challenge.
   - Challenge topics may include standard science problems, such as the following: find a way to pick up a steel nail without touching it; invent a new drink container that will not spill its contents.
   - Use your imagination to create challenge topics. Example: "What if a huge cloud permanently settled in our atmosphere, preventing sunshine? How would this change affect our daily lives?"
2. Create a challenging physical environment.
   - Set aside storage spaces and stock storage shelves or boxes with all sorts of materials: jars, aluminum cans, pieces of wood, tape, glue, tempura paints, tools, lots of interesting "junk", and an occasional bit of scientific apparatus or art materials.
   - Set up simple tools and work surfaces, or designate floor space as awork area.
3. Create a think tank.
   - Fill three containers with small cards listing hundreds of random nouns, adjectives, and verbs.
   - Each student chooses three words (a noun, an adjective, and a verb), defines the function each word implies, and tries to solve a problem by using word association or by developing a think drawing. Example: Redesign a paper bag.

Discovery and Invention

Here are two excellent classroom activities that help students distinguish between a discovery and an invention. First, ask the students to define the terms discovery and invention and then begin the activities.

Discovery and Invention, Activity 1*

Part A:

For each statement, tell whether you think it describes an "invention" or a "discovery."

1. Columbus finds America.
2. John comes upon Mary's lost book, lying on the floor.
3. Mary thinks up a new way to string beads.
4. A scientist doing research finds out how human cells can become cancerous.
5. A family makes a new device that automatically feeds the dog while they areaway from home.

Part B:

In your own words, describe the difference between the actions you call "discovery" and those you call "invention".

Part C: Exercise - Discover, Invent, and Reveal

Read the definitions given here:

Discover - to find out, realize, learn of the existence of.
Invent - to think up, devise, think out, produce, originate.
Reveal - to make known, disclose, show.

In each of the sentences below, choose one of the three words. Write your choice in the appropriate place.

1. Whenever I need help in class, I look on the ceiling to see if I can find the answer ______________________________ to me.
   (revealed, invented, discovered)
2. Scientists ought to ________________________ a way to save energy.
   (invent, discover, reveal)
3. Horace P. Puffy was the ______________________ of a new method of baking donuts. (discoverer, inventor, revealer)
4. The ________________________ of the printing press made it easier to publish books. (revealing, discovery, invention)

Part D:

Discuss why you answered Part C as you did.

---

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Discovery and Invention, Activity 2**

Part I: Classify the following and provide reasons for your choices:

	Discovery	Invention	Reasons
1. Electricity	____	____	____________________
2. Electric light bulbs	____	____	____________________
3. Magnetism	____	____	____________________
4. Magnets	____	____	____________________
5. Papyrus	____	____	____________________
6. Television	____	____	____________________
7. The Pacific Ocean	____	____	____________________
8. X-rays	____	____	____________________
9. Soap	____	____	____________________
10. Printing	____	____	____________________
11. Thinking	____	____	____________________
12. The family	____	____	____________________
13. The city	____	____	____________________
14. Pasteurized milk	____	____	____________________
15. Candied apples	____	____	____________________

Part II: Discovery and Invention

Have your students write a paragraph on one of the following topics:

a. My Greatest Discovery
b. The Difference Between Discovery and Invention
c. What I'd Like to Invent
d. Can People Discover Things Together?
e. Are All Discoveries Inventions?
f. Are All Inventions Discoveries?

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Categories of Inventions and Innovations

Most inventions and innovations will fall into at least one of the following ten categories. Several examples are given for each category.

Culture: Religions (objects, buildings, clothing, jewelry); the family (rituals of birth, marriage, death); the city (government, social activities); systems (assembly line, supermarket).

Communication: Alphabet, number systems, pencil, markers, telegraph, telephone, computers.

Clothing: Loom, buttons, zipper, laces, velcro, synthetic fabrics.

Entertainment: Sports (games, equipment, stadium, uniforms); music (instruments, notation, phonograph, cassettes, compact discs, VCRs); art (paints, brushes, canvas, camera, film); toys, puzzles, novelties.

Energy: Lantern, windmills, light bulbs, batteries, refining petroleum, solar panels, nuclear power.

Food/Agriculture: Utensils, matches, plow, appliances, synthetic foods (frozen, instant, freeze-dried, processed), ice cubes.

Health: Medicines, microscope, stethoscope, antibiotics, vaccinations, bandages, X-rays, artifical organs, contact lenses, laser bonding in dentistry.

Shelter/Home: House (windows, doorknobs, locks, steps), pillows, furniture, appliances, geodesic dome (for example, the Astrodome stadium in Houston, Texas), skyscrapers.

Transportation: Raft, wheel, train, sails, rails, spacecraft

Weapons/Military: Arrowheads, bow and arrows, guns, atomic bomb.

Some objects, such as tools, will fit into virtually every category. Others, like the paper clip and the safety pin, will be difficult to categorize.

Activities:

1. Cut out pictures of inventions and innovations from magazines and newspapers. Ask the students to sort the pictures into the categories listed above. Place the ten category labels and their corresponding pictures on a bulletin board or glue them on oaktag or large paper. This is an excellent sorting activity for young children.
2. Trace the progress of inventions in one particular category. Try to think of the earliest invention in each category. Ask the students to "predict" future inventions in each category. "Predictions" may be verbal, written, or drawn.

Invention Activities

1. Pass around an unusual gadget from home. (Tupperware gadgets are great!) Ask the students to guess the use of the item. Homework assignment: Ask the students to look around their homes and find an unusual item to bring in the next day. It's a new twist on "Show and Tell."
2. List items whose origins predate World War II (e.g., inkwells, icebox, 78 records, slide rule, dirigibles). Are these items now obsolete? Discuss why they are no longer useful. Have they been replaced by something else? If so, what and why?
3. Make a list of inventions which have become known by their brand names: Scotch (cellophane) tape, Aspirin (Bayer's original trademark), Kleenex (tissues), Jello (gela tin), Coke (cola soda).
4. List inventions which were named after their inventors (e.g., Mason jars, Yale locks, Tupperware, Birdseye frozen foods).
5. Find pictures of very new inventions: paper bottle (juice boxes), velcro, extended wear contact lenses, laser compact discs (CDs). Why have they become so successful?
6. List songs which use technology or an invention as a theme. See if you can locate recordings of these songs.
7. Refer to the definition of the word "machine" in the Definitions section of How to Get Started. The average family uses hundreds of machines. Inspect your house and list any machine you find. (Remember that a potato peeler, a baby carriage, a tire jack, and a thermostat are machines.) Show the list to your family and ask each of the following questions:

   - Which machine is the most important to you?
   - Which one would be the hardest to do without?
   - Which one do you enjoy the most?
   - Which ones should you not have bought?
   - Which ones did not exist when your parents were your age?
   - Which ones did not exist when your grandparents were your age?

Present the results of the final two questions to chart form. Use the following labels as the column headings of your table: machine, parents didn't have, grandparents didn't have.

8. Draw a comic strip that shows the story of how one particular invention came about.
9. Make flash cards or playing cards to match inventors and their inventions.
10. Research the inventors and the dates of the following inventions, innovations, and adaptations.

air conditioning
bikini
can opener
color photography
Dr. Pepper
elevator
escalator
frozen foods
go-cart
gummed envelopes
ice cream cone
in-flight movie
margarine
mimeograph
Teflon
Noxzema
nylon stockings
parking meter
pencil
photocopier
potato chip
roller skates
safety pin
safety razor
soda pop
sugar cubes
supermarket
zipper

Activity

Practicing Inventive Thinking with the Class

Before your students begin to find their own problems and create unique inventions or innovations to solve them, you can assist them by taking them through some of the steps as a group.

- Finding the Problem - Let the class list problems in their own classroom that need solving. Perhaps your students never have a pencil ready, as it is either missing or broken when it is time to do an assignment. Select one problem for the class to solve using the following steps:

1. Analyze the situation.
2. Think of many, varied, and unusual ways to solving the problem. List the possibilities. This is called "brainstorming." Be sure to allow even the silliest possible solution, as creative thinking must have a positive, accepting environment in order to flourish.
3. Select one or more possible solutions to work on. You may want to divide into groups if the class elects to work on several of the ideas.
4. Improve and refine the idea.
5. Share the completed idea and evaluate it.

Activity

Practicing the Creative Part of Inventive Thinking

Inventive thinking includes both creative and critical or analytical thinking skills. There are many quick activities that can be used to develop creative thinking in any subject area. The following list of ideas can be expanded and used in a variety of ways throughout the year.

- Bring in any object or use objects around the classroom to do the following exercise. The children should be able to list many new uses for a familiar object by using the list of questions below with regard to the object. Use a paper plate to begin, and see how many new things the students will discover.
- What is it made of? Could it be made from something else?
- To what new use(s) can I put this?
- How can I add to it or what can I add to it to change its use?
- Can I take something away from it and make it smaller?
- Could something else be substituted for it?
- Can it be reversed or rearranged?
- Can it be combined with something else to make something new?
- Using literature, ask your students to create a new ending to a story, change a character or situation within a story, or create a new beginning for the story that would result in the same ending.

When students have discovered a product or process to invent, they should complete an Intent to Invent form. This form provides a brief description of the product or process to be invented.

INTENT TO INVENT FORM

Student Name________________________ Date________________________

What are you going to call your invention?______________________________

A brief description:____

____

____

____

____

____

What do you need for materials? ____________________________________

____

____

____

____

____

The Qualities of a Good Invention

A good invention should have three qualities: need, practicality, and originality. The inventor should determine the criteria necessary to evaluate each invention. Here are some suggested questions the inventor might ask.

Need:

1. Is my invention needed?
2. List the possible advantages and disadvantages of the invention.
3. Who will be the user? Who will not be able to use it? Will it be useful to all age groups and both sexes? Is it designed for a special group?
4. Is it designed for entertainment or decoration?
5. Is it designed to improve the environment?
6. Will it improve my life? Will it make a task easier or faster to perform?

Practicality:

1. When is the invention used? When can't it be used?
2. Where is it used? Where can't it be used?
3. How is it used? How can't it be used?
4. Is it too complex? Too simple? Is it easy to use?
5. Is it too heavy or too light? Is it too big or too small? Is it easily damaged?
6. Can it be made inexpensively? Will I make a profit? Can it be mass- produced, or do I have to make each copy one at a time?
7. Does it save money? Does it save time?

Originality:

1. Is there something similar to my invention already available? Is my invention different enough from what is already in existence?
2. Is my invention creative or unusual?
3. Is it cleverly names?
4. Is it neatly draw or constructed?
5. Is it made from ordinary materials? Can it be made from recycled materials?

Activity

Which of the five senses does the invention involve? Think of other inventions which are based on each of the five senses: sight, smell, hearing, touch, and taste. Use the chart below to list each invention under the appropriate sense. Try to make your invention appeal to as many senses as possible.

SIGHT	SMELL	HEARING	TOUCH	TASTE

Step III Research and Planning:

Students should create detailed plans for their invention or process. In the plans, the developmental steps are laid out, preliminary drawings may be made, time limits are established, materials are listed, and testing methods are defined.

During the planning step, students must decide whether they will produce a small model or a full-size prototype of their invention. Students inventing a new process will want to develop an outline for their report.

The Student Log

Like most scientists, Thomas Edison kept notes as he performed his experiments. He recorded his observations (what he saw, smelled, and heard) and what he learned as he went along.

Students should compile notebooks for recording their experimental observations. The best and most convincing way to document an idea is to keep a witnessed diary or log. "Witnessed" means that someone should read the entries periodically and initial them. A school notebook, with lined paper and a red line at the left margin, may be used. Comments, corrections, and initials may be placed in the left margin.

The student log should be a complete record of everything having to do with the student's idea:

- How the student got the idea for the invention.
- Background information regarding the invention.
- How the student developed the idea.
- Problems encountered.
- Progress made.
- Calculations, measurements, estimates.
- Drawings, sketches, and plans.
- Test results.
- Photographs taken by the student.
- Names of people with whom the student talked and what they contributed.

The student should periodically give the log to the sponsor. The witness should sign and date the page under the words "read and understood by me."

The student should continue to keep the log until development of the invention is completed. This procedure is the next best protection to filing a patent application.

Step IV Developing and Testing:

In this step, students build their invention or develop their process. They will learn that plans need to be changed along the way and that trial and error is a part of the invention process. In addition, they should do appropriate testing and record any necessary data for their test report.

The culmination of this step will be completion of the Patent Application. The application form that follows has been modeled after the official U.S. Patent Office form and should be "notarized" by the school principal.

PATENT APPLICATION

As the inventor named at the bottom of this page, I hereby declare that my school address and citizenship are listed below my name. I truthfully believe that I am the original, first, and only inventor of the invention entitled:

____

I have described my invention in detail on the page attached to this application.

DECLARATION

I do not know and do not believe that the invention was ever known or used in the United States of America before I invented it.

I do not know and do not believe that the invention was ever patented or described in any book, magazine, or newspaper in any country before I invented it.

I do not know and do not believe that the invention was in public use or on sale in the United States.

FULL NAME OF INVENTOR ______________________________

GRADE LEVEL ____________ TEACHER ______________________

PRINCIPAL ______________________________________

FULL NAME OF SCHOOL ______________________________

STREET ADDRESS OF SCHOOL __________________________

CITY ____________________ STATE ________ ZIP __________

CITIZENSHIP _____________________________________

SIGNATURE OF INVENTOR ____________________ DATE ________

FOR OFFICE USE ONLY

OFFICIAL APPLICATION
NUMBER ______

____
SIGNATURE OF TEACHER

____
SIGNATURE OF PRINCIPAL

Step V The Invention Convention:

The invention convention is the event students have been waiting for. It provides each qualifying student with an opportunity to display his or her project. On the designated date, students will bring their inventions to the selected convention site. Here the inventions will be officially judged, and awards will be presented. The invention convention will be open to the public, and students should be present to answer questions about their inventions. Keep in mind, everyone is a winner.

If you plan to evaluate the projects, the judging form that follows may be of value.

THE INVENTION CONVENTION JUDGING FORM

Date of Convention______________________________

Name of Inventor______________________ Grade Level__________

Title of Invention______________________________

Circle the appropriate rating for each item - (5 = Superior; 1 = Unsatisfactory)

1. The invention reflects original, creative thought.

   5 4 3 2 1

2. The invention has practical value.

   5 4 3 2 1

3. The inventor has provided sufficient evidence to show that no similar process or product exists.

   5 4 3 2 1

4. The inventor is knowledgeable and enthusiastic about his or her invention.

   5 4 3 2 1

5. The invention is carefully designed and/or constructed.

   5 4 3 2 1

6. The inventor has made wise use of available materials and resources to control costs.

   5 4 3 2 1

7. The inventor has promoted his or her invention effectively with eye-catching and creative promotional materials.

   5 4 3 2 1

TOTAL POINTS__________

FINAL RATING:

____Superior (34-35 pts.) ____Excellent (30-33 pts.) ____Good (24-29 pts.)

____Fair (19-23 pts.) ____Unsatisfactory (<19 pts.)

Judge's Signature______________________________

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Chapter 13
POSTTEST

Did I Really Learn Something? (Component 10.0)

Tests are bad news. They are great instruments to intimidate students. It is hoped that the learning experiences in this course have not intimidated all but the very bright. If teaching has been effective, most students should do well on exams.

The midterm and final should not:

1. Fit the "Guess What?" format.
   It is not the intent for you to know everything. You should not memorize this book. Highlights presented in class and in the text should eliminate some of the guessing. Student outcomes listed in Chapter 2 should help organize your study.

2. Fit the "Gotcha" syndrome.
   Nothing in an exam should be intended to trap the student. Assigning a large number of points to triva is not justified. Everything covered in an exam should be of major importance.

REMEMBER!!!

Test Item Discriminability

What causes S to pass or fail the item? That is what the test measures.

We don't need tests to discriminate those who are smart from those who are dumb. We need tests to discriminate those who have mastered and those who haven't mastered what we taught.

If the cause of passing or failing a test item is not the effect of instruction, the test item is **misaligned** with the instruction.

TEACH FOR THE TEST//TEACH FOR THE TEST//TEACH FOR THE TEST

Outline of the Perfect Lesson

1. Display the posttest.
2. Teach the lesson with the posttest up front.
3. Practice the posttest until perfect performance.
4. Now give the posttest.

Eeh gads, everyone got an A! What kind of world would it be if everyone got an A?

THE OUTCOME IS THE POSTTEST
TEACH TO THE OUTCOME
TEACH TO THE TEST

5 Ways to Ask the Same Question:

WHAT KIND OF PEOPLE DO I WANT THEM TO BE?
WHAT SHOULD THE OUTCOME BE?
WHAT'S WORTH TEACHING?
WHAT SHOULD I TEACH?
WHAT SHOULD I TEST?

SO WHAT'S THE POINT?

ANSWER: Teaching is a helluva serious business.

The section that follows contains items from some previous exams. These should help provide familiarity with the kind of items to expect. It might help you to match them with student outcomes listed in Chapter 2.

1. Define science:
2. How do Project Learning Tree or Water Education materials facilitate to multidisciplinary approach to science teaching.
3. True-False. The comprehension level component of scientific literacy can be higher than the application level component of scientific literacy for a given concept.
4. Identify and describe five safety hazards and accompanying safety precautions that might be encountered when teaching elementary science.
5. Describe in detail one first generation elementary science curriculum.

Pick the best answer:

6. Science is:
   ___a. a human endeavor
   ___b. always right
   ___c. infallible
   ___d. never right

7. In order to determine the cause of disease X, one thousand people with the disease were examined. All had Bacteria Q in their mouths. The conclusion reached was that Bacteria Q is the cause of the disease. Which of the following can BEST be said about the above?
   ___a. The conclusion is false because the data do not support it.
   ___b. The conclusion does not deal with the problem.
   ___c. The conclusion is a good one because the data support it.
   ___d. No conclusion should be made until people without the disease are examined.
   ___e. I don't know.

If these are not of much help, perhaps we should use the grading procedure that follows:

Grading Factors	PROPOSED GRADING SYSTEM				
	A	B	C	D	E
Quality	Leaps tall buildings with a single bound.	Must take running start to leap over tall buildings.	Can leap over short buildings.	Crashes into buildings when trying to leap over them.	Cannot recognize buildings at all.
Timeliness	Is faster than a speeding bullet.	As fast as a speeding bullet.	Not quite as fast as a speeding bullet.	Would you believe a slow bullet.	Wounds self with bullets when shoots.
Initiative	Is stronger than a locomotive	Is stronger than a bull elephant.	Is stronger than a bull.	Shoots the bull.	Smells like a bull.
Adaptability	Walks on water constantly	Walks on water in emergencies.	Washes with water.	Drinks water.	Passes water in emergency.
Communication	Talks with God.	Talks with angels.	Talks to self.	Argues with self.	Loses those arguments.

Appendix 2

Methods Course Curriculum Improvement

METHODS COURSE CURRICULUM IMPROVEMENT

a
Users Manual

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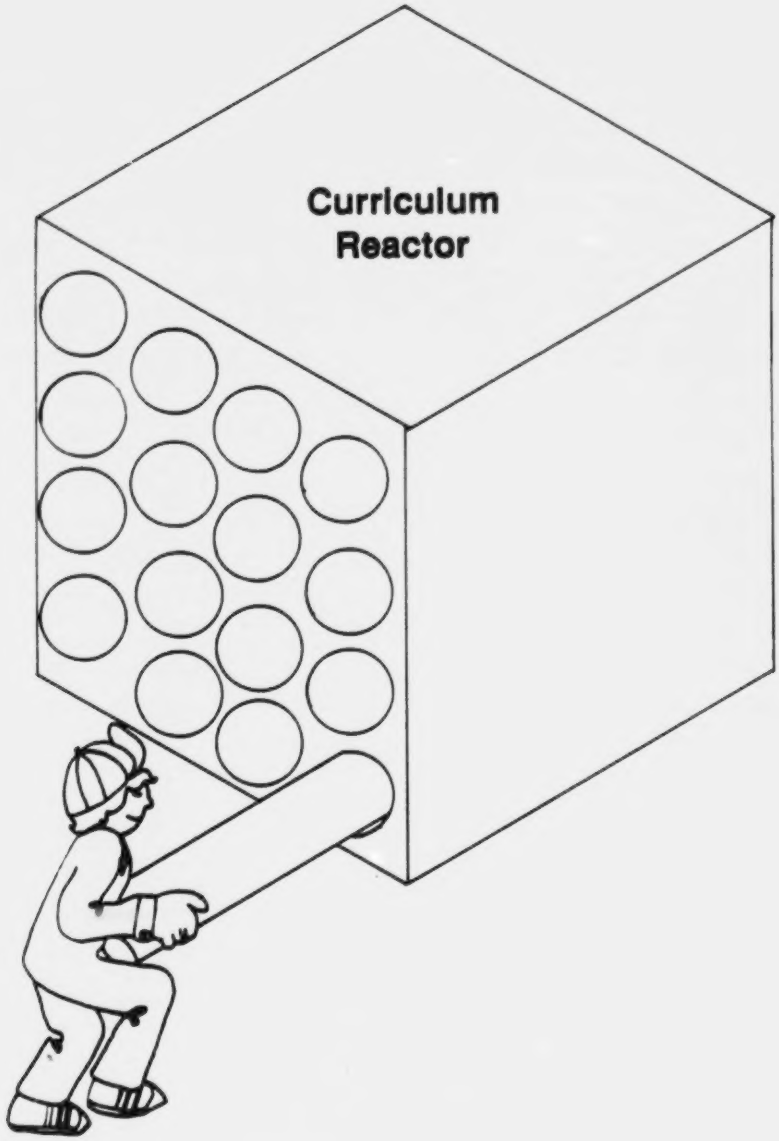
Chapter 1
CRITICAL MASS


Curriculum
Reactor

Introduction

The basic purpose of this publication is to provide a practical "how to" manual for curriculum development at the university level. The principles included in this approach were tested over time. Initially they were used to facilitate curriculum development at the local level; ranging from experience with public school programs to a complete revision of a college nursing program. This know-how was then applied to improvement of the science methods component of the elementary teacher preparation program at Utah State University.

Education faculty certainly have access to many books, manuals, and papers on curriculum development. Current literature is very comprehensive and sound. The "how to" of this text was based on this existing sound academic background. The manual is long on doing and short on theory. As part of the "doing", the reader will be asked to complete specified tasks throughout the text.

The Reactor

In Nuclear fission a radioactive element such as uranium is used to fuel a self-sustaining, energy-producing process. Reactors consist of a large block of inert material, with rods of fuel inserted into the block. As the rods are inserted, a certain critical mass of fuel is achieved and the reaction proceeds in a controlled, self-sustained reaction.

The initial steps in producing an innovative methods course involves getting together a critical mass. These steps are basic to the smooth operation of the entire process. Not only must the "rods" be the right ones, they must be inserted into the inert blocks in the proper way and order.

The section that follows discusses the basic components (rods) that must be inserted into the block in order for the process to operate. These include the project director, the advisory committee, a viable teacher preparation program, and well-qualified students.

Chapter two discusses the foundation upon which the reactor rests. This foundation consists of a curriculum, facilities, materials, and the money needed for for operation.

Chapter three contains a detailed analysis of how everything is put together.

The Prime Mover

Any curriculum development process requires a responsible agent. This person should be highly competent in the subject matter area under consideration, have curriculum development skills and experience, and be able to work well with people. These characteristics are listed in what is probably the reverse order of importance.

The prime mover is normally the project director. This person must have time available to work on the project. If the project director is a faculty member rather than an administrator, then some consideration must be given to the teaching/research role. Curriculum development involves much time and effort.

It would be very helpful if the project director were a recognized faculty person. A good reputation across campus is a great asset in dealing with other colleges and departments.

If no one is available with all of the above qualifications, then pick the person most qualified and/or most willing to take on the task. The project director must be willing to be responsible for both the process and the product. If things go right, it is the team's credit; if they go wrong, it is the project director's responsibility.

The Advisory Committee

A functioning advisory committee is vital to any curriculum development project. This group not only supplies administrative support and ideas, it is the ownership "body" that assesses success of a project. No matter how well qualified the project director is, no one person can succeed in the development of an innovative methods course.

It is important that the project director's department and college are represented on the advisory committee. Ideally this would include the department head, the dean, and one or more other interested faculty.

Another very vital component is the college that represents the content component of the methods course under consideration. For example, if the science methods course is being revised, then the college of science should be involved. It is recommended that college representation include the dean, department heads of the appropriate content-related departments, and representative faculty that teach the related content courses.

The advisory committee is rounded out with students, classroom teachers, and school administrators.

A Viable Teacher Preparation Program

Methods course improvement should operate within the framework of an existing teacher preparation program. For the purposes of this manual there are no preconceived notions about what constitutes a good teacher preparation program. However, there must be a measure of congruence between the philosophy and objectives of the total program and the philosophy and objectives of the methods course under development.

Competent Instructors

The quality of instruction in both content courses and in the methods courses can not be overemphasized. Administrators must be willing to assign highly-qualified faculty to teach the courses involved in the program. These faculty need to teach the courses on a regular basis. Quality control over time is vital.

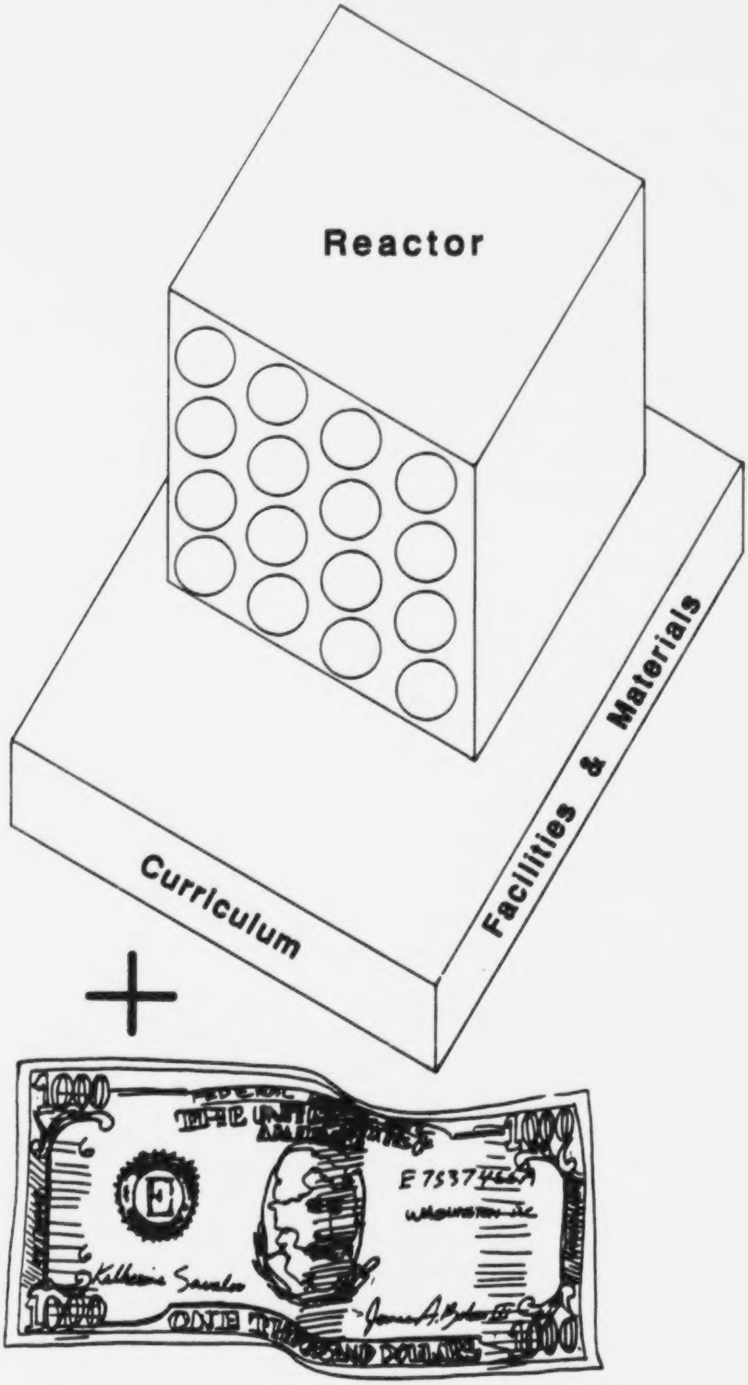
High standards of student performance are important. Education students enrolled in general education courses and required content courses should receive the same instruction and compete for grades with the general population of university students. Minimum standards of acceptance and maintenance in a program should serve as a screening device to limit completion to only qualified students.

Well-Qualified Students

High standards of students' performance are important. Education students enrolled in general education courses and required content courses should receive the same instruction and compete for grades with the general population of university students. Minimum standards of acceptance and maintenance in a program should serve as a screening device to limit completion to only competent students.

Chapter 2

A FIRM FOUNDATION


Reactor
Curriculum
Facilities & Materials
+
1000
ONE THOUSAND DOLLARS

Facilities and Materials

In the previous section entitled critical mass, emphasis was on human resources. In this section, non-human factors will be discussed. There is no intent to infer that either is more important, or that one should precede the other.

Classroom facilities, equipment, and materials are needed to meet the goals and the objectives of content and methods courses. These, of course, cannot be specified before the course outlines are produced. However, one of the keys to adequate facilities is to think in terms of the entire community. Across-campus access and public school access greatly increases potential for resources.

Task #1: List Resources

Purpose: To initiate thought about the big picture of facilities and resources that impact your program.

List all of the human and physical resources that are currently a part of your program.

HUMAN RESOURCES	PHYSICAL RESOURCES
1.	1.
2.	2.

What other resources would you like to add?

Curriculum

Curriculum means different things to different people. Below are quotes from various sources using the word "curriculum," each with a different meaning.

> "Yer out!" screams a synchronized formation of prospective umpires, and up go fists to prove it. Hand signals, like proper stance, voice control, interpretation of the rules and the handling of tough situation, are all part of the school's curriculum.[1]

> After an extensive survey of its curriculum, Yale's committee has issued several proposals. It points out that students have become so involved in extracurricular pursuits that they have come to favor the football over the pencil. The report continues by setting up an elaborate system under which activities would be safely submerged in the academic curriculum.[2]

> There is widespread dissatisfaction among physics teachers over the present curriculum.[3]

> A curriculum is something to be felt rather than something to be seen. The transplanting of the structural aspects of a promising (elsewhere) program tends to overlook the fact that the true blueprint is in the minds and ears of the teachers.[4]

> The curriculum is a cultural yardstick.[5]

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[1] Caption to a picture in Sports Illustrated describing a school for baseball umpires.

[2] Editorial in the Pennsylvania News, an undergraduate newspaper at the University of Pennsylvania.

[3] Report from the Physical Science Study Committee established by the National Science Foundation.

[4] Harold Spears (1970). The School for Today. New York: American Book Company, p. 27.

[5] G. Robert Koopman in an address to the 35th Annual Convention of the Council for Exceptional Children.

Task #2: Define Curriculum

Purpose: To arrive at a working definition of curriculum.

List the things that come to mind when you hear the word "curriculum".

Formal Definition of Curriculum

Curriculum is. . .

The following is a working definition used by the authors:

> "Curriculum is a plan for providing various types of learning experiences designed to achieve broad goals and specific objectives for a target population of students."

How does this definition compare with your definition?

How would you modify either your definition or the one stated above?

Money

Finance and fiscal matters should not be separated from the creative process. All persons involved in a project will be aware that there is always a cost. Cooperative informed management will contribute to a project's success.

Anticipated project costs, including a reasonable overhead rate, should be calculated even if there is no external funding. If a grant proposal is being written, the request for proposals will usually specify budget items to be considered. Budget items need to match the plans and functions of the project.

The section that follows contains a skeletal outline for a project budget. If the budget is extended over a number of years, a separate budget should be made out for each year of the project.

Sample Budget

I. Personnel	
1. Project Director	____
Release time: 1/4 FTE Equivalent for 12 mos.	
2. Writing Team	____
2 persons full time for 6 mos. @ ___ per mo.	
3. Secretarial	____
1 person full time for 12 mos.	
4. Employee Benefits	____
__ % of salaries = ___	
TOTAL PERSONNEL	____
II. Other Direct Costs	
1. Consultants	____
Art Work ___	
External Evaluator ____	
2. Advisory Committee Honoraria	____
10 persons @ ___ = ___	
3. Travel	____
Advisory Committee ___	
4. Office Supplies	____
Paper and Copying ___	
5. Communications	____
Phone ___	
6. Equipment Rental or Maintenance	____
Word Processing ___	
TOTAL DIRECT COST	____
III. Indirect Cost	
Computed at __% of TDC =	____
TOTAL PROJECT COST	____

Chapter 3

Processes and Procedures

Reactor
Users
Manual

This chapter contains the substance of the process for developing a course or program. Basic steps are outlined in some detail. Procedures may be adapted to local needs and interests, however, each step needs to be considered in some way.

It is assumed, at this point, that the prime mover (project director) has been identified. At this point in the curriculum development process, the advisory committee may be rather informally constituted. The advisory committee should work through a review of the literature and help form a draft philosophy statement.

Step 1: Review of Literature

The project director needs to carry out an extensive review of literature related to the area under revision. Of particular concern is "What does research have to say about the subject." However, the authors have found that practical "how to" articles contribute greatly to a working philosophy.

The primary purpose of the review is to establish a sound foundation for a philosophy. The authors have found that concept mapping is a very useful tool in organizing the review of literature. A concept is defined by the authors as a regularity in events or phenomena that can be designated by a symbol. Concept maps represent relationships between concepts. The relationships are normally expressed in the form of language phrases. A phrase is made up of two or more concepts linked by words to form a meaningful unit, e.g. grass is green.

A sample concept map with map rules follows:

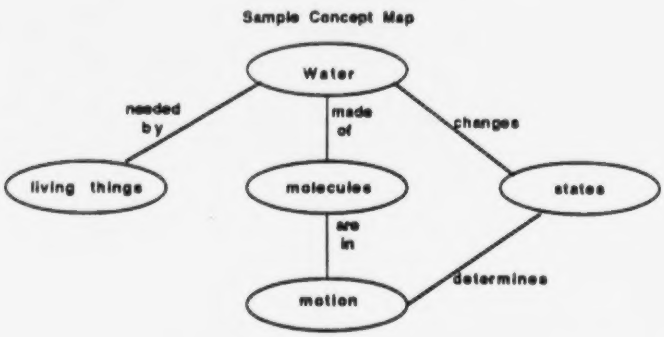

Sample Concept Map
Water
needed by
made of
changes
living things
molecules
states
are in
determines
motion

Figure 1: Sample Concept Map

Rule 1: Concept map should be hierarchical
general at top
specific at bottom

Rule 2: Meaningful relationships are indicated by a connecting line and linking words.

Rule 3: Cross links show connections between segments.

In a recent project revising a social studies methods course, the following concept map was used to help organize the review of literature:

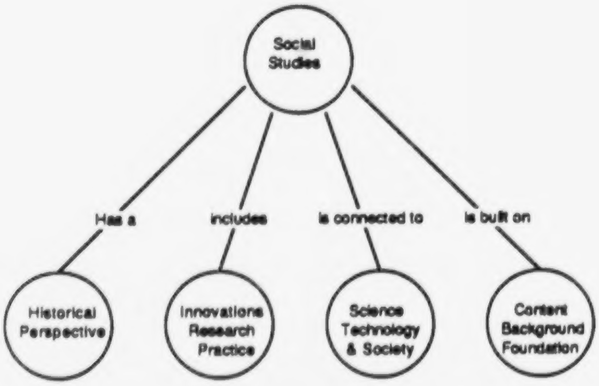

Social Studies
Has a
includes
is connected to
is built on
Historical Perspective
Innovations Research Practice
Science Technology & Society
Content Background Foundation

Figure 2. Social Studies Concept Map

This simple concept map was then further expanded by listing the components of each of the four major areas. The result was a simple outline to organize the review of literature.

Task #3: Program Concept Map

Purpose: To help organize a review of literature.

What are the important aspects of your program? Organize them in the form of a concept map. Have a number of people perform the same task and compare results. Assemble these into a composite concept map.

The products of the review of literature need to be organized in a readable form. The project director will share this information in draft form with the advisory committee.

Step 2: First Draft of a Philosophy

What is "Philosophy"

Hopkins Expressed the importance of philosophy in determining curriculum:

> Philosophy has entered into every important decision that has ever been made about curriculum and teaching in the past and will continue to be the basis of every important decision in the future. The belief of the Protestant reformers that each person must read the Bible to achieve individual salvation led to the Massachusetts Law of 1647 requiring towns of fifty householders to maintain a reading and writing school. Because the Puritans "dreaded to leave an illiterate ministry to the churches when our present ministry shall lie in the dust," they established Latin Grammar School under other sections of the same law. Reading and writing are still taught in the elementary schools, and Latin is still taught in some secondary schools, even though both are justified on quite different beliefs from those which brought them into the curriculum. When a state office of education suggests a pupil-teacher time schedule, this is based upon philosophy, either hidden or consciously formulated. When a course of study is prepared in advance in a school system by a selected group of teachers, this represents philosophy because a course of action was selected from many choices involving different values. When high school teachers assign to pupils more homework for an evening than any one of them could possibly do satisfactorily in six hours, they are acting on philosophy although they are certainly not aware of its effects. When a teacher in an elementary school tells a child to put away his geography and study his arithmetic she is acting on philosophy for she has made a choice of values. If she had allowed the child to make the choice she would have been operating under a different set of beliefs. Many persons believe that children can best be educated to live in a democracy by rigid authoritarian control through the adolescent period. Others believe that democratic interaction should be practiced as soon as the child is capable of distinguishing among subjects, situation, activities, which is a number of years before he usually enters school. When teachers shift subject matter from one grade to another, they act on philosophy. When measurement experts interpret their test results to a group of teachers, they act upon philosophy, for the facts have meaning only within some basic assumptions. There is rarely a moment in a school day when a teacher is not confronted with occasions where philosophy is a vital part of action. An inventory of situations where philosophy was not used in curriculum and teaching would lead to a pile of chaff thrown out of educative experiences.[6]

---

[6] Hopkins, L. Thomas (1941). Interaction: The Democratic Process. Boston: D.C. Death and Co., pp. 198-200.

In simplistic terms, philosophy is what we believe. In rational terms, philosophy should be greatly impacted by the review of literature. In practical terms, the project director will intuitively select many tenets that support preconceived notions. The philosophy will reflect basic values and beliefs. It will be the task of the project director to present a philosophy to the advisory committee in an acceptable and convincing form.

Task #4: First Draft of a Philosophy

Purpose: To use the concept map and review of literature as organizers to write a first draft of a project philosophy.

Write a draft of your program philosophy. SPACE FOR THIS TASK IS NOT PROVIDED HERE. This will be a major document. See: Daugs, D.R., Foundations for an Elementary Science Methods Course. Logan, UT. Utah State University. (ERIC Document Reproduction Service No. ED272 390) for a sample philosophy.

Step 3: Formation of An Advisory Committee

The advisory committee is both an important political and a working body. The project director, department head, and dean should work together to form a group that will help maximize project success.

Important items to consider in selecting committee members include:

1. Who should play what roles in the curriculum development process? What roles should be played by colleges, departments, students, and public school teachers? Who are the experts in the field?
2. In situations where values conflict, whose values should be embodied in the program? How should these issues be decided?
3. Should the state education agency be involved in the process?
4. How can local (market place) concerns be best incorporated into the program?
5. Who will be most able to facilitate any substantive curriculum changes?

Task #5: Potential Advisory Committee Members

Purpose: To assemble a list of people who can best facilitate program development.

Consider the items in the first part of step 3. Who do think should be involved in the project? For each person listed also state the reasons they should be on the committee.

Person	Reasons

In consultation with the dean of education and department head, review your list of potential Advisory Committee Members. The dean should contact potential members, briefly explain the project, invite participation, and call and conduct the first meeting. Unless it is a meal meeting, the first session should be 30-45 minutes. The agenda for the first Advisory Committee may include:

Advisory Committee Agenda

Item	Person Responsible
Introductions	Dean
Project Overview/Questions	Project Director
Proposed Procedures	Project Director
Philosophy Draft	Project Director
Task Outline/Next Meeting	Project Director

The task outline component of the meeting should include a discussion of broad goals, but emphasis should be on the desire that the Advisory Committee become the guiding body for the project. The purpose of the philosophy draft is to provide the Advisory Committee with a starting point and something to chew on.

The proposed procedures part of the meeting provides a basis for understanding the entire curriculum development process and committee involvement. The diagram below may be helpful in sharing this process.

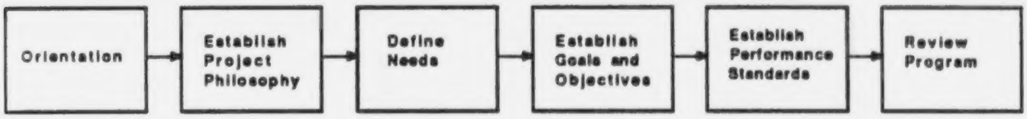

Orientation
Establish Project Philosophy
Define Needs
Establish Goals and Objectives
Establish Performance Standards
Review Program

Figure 3: Advisory Committee Functions

Once the program is established, the Advisory Committee may need to meet only once a year. Initially, meetings/working sessions may need to be scheduled monthly.

Step 4: Establishing a Project Philosophy

The first task of the Advisory Committee will be to review the draft philosophy and revise it to reflect the thinking of the entire group. It has been the experience of the authors that a well-documented research basis for a philosophy is hard to argue with. The key in the revision process is to have a workable philosophy.

The project director should conduct as many working sessions as needed to arrive at a sound background philosophy.

The philosophy should either implicitly or explicitly identify project needs. After a final draft of the philosophy is provided, an Advisory Committee session should be devoted to identifying needs. Use the philosophy document and brainstorm needs.

Task #6: Project Needs

Purpose: To provide a transition from a philosophy to project goals and objectives.

List possible program needs that have been identified in the philosophy.

It may also be helpful to prioritize the needs. Supply Advisory Committee members with a list of the needs identified in the previous session. Ask them to rate each item on a scale of 1-5 with 1 = very important, 2 = important, 3 = a nice frill, 4 = not really needed for success of the program, 5 = irrelevant item. Assemble the data and calculate an average score for each item. Then rank items by average score. Highest ranking items must be seriously considered when writing goals and objectives.

Step 5: Curriculum Plan

The flow chart in figure 4 illustrates all of the components of the basic curriculum development plan.

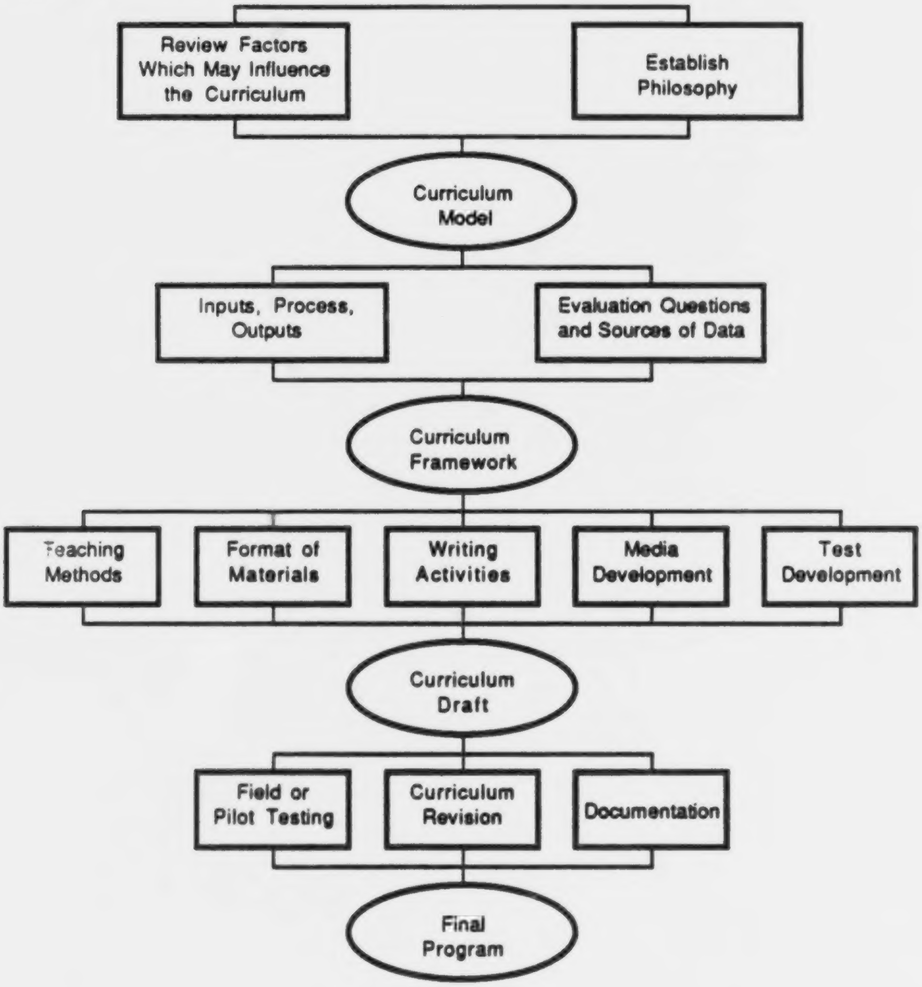

Review Factors Which May Influence the Curriculum
Establish Philosophy
Curriculum Model
Inputs, Process, Outputs
Evaluation Questions and Sources of Data
Curriculum Framework
Teaching Methods
Format of Materials
Writing Activities
Media Development
Test Development
Curriculum Draft
Field or Pilot Testing
Curriculum Revision
Documentation
Final Program

Figure 4: Basic Curriculum Development Plan

The major responsibility for all components of the plan rest upon the project director. The Advisory Committee should be used as a sounding board as the process proceeds. The components of the plan are not discussed at this point but will be detailed in the steps that follow.

Step 6: More Help (A Writing Team)

The authors' motto has always been, "No one of us is as smart as all of us." Depending on resources, the project director needs to assemble a writing team. This team may include members of the Advisory Committee, students, or even hired help. Size of team is directly related to dollar resources. Selection should emphasize the need for professionals who know most about the subject matter area and teaching/learning. Traits to look for in potential members of a writing team include:

1. Experience with children
2. Knowledge about the learner
3. Background in the discipline
4. Appreciation for interdisciplinary interactions
5. Task oriented
6. Willing to change
7. Able to cope with negative feedback
8. Work effectively with others
9. Have time free to work on project

Task #7: Form a Writing Team

Purpose: To expand the human resources needed to complete the project.

List the names of potential team members. Assess their potential as team members in terms of the items listed above. Then pick those that best match project needs and dollar resources.

Name	Strengths & Weaknesses	Estimated Cost

Step 7: A Curriculum Model

Often the program, as conceived up to this point, can be more easily perceived when presented in the form of a model. A curriculum model may reflect scope and sequence of a curriculum, rationale, factors influencing the curriculum, philosophy, etc. Models may take the form of point-by-point lists, narratives, diagrams, charts, drawings, and/or combinations of the above. Models may be multidimensional with no moving parts or have moveable parts that show options of various avenues of approach. Facets may include processes, skills, content, learner's characteristics, organizational levels or teaching themes.

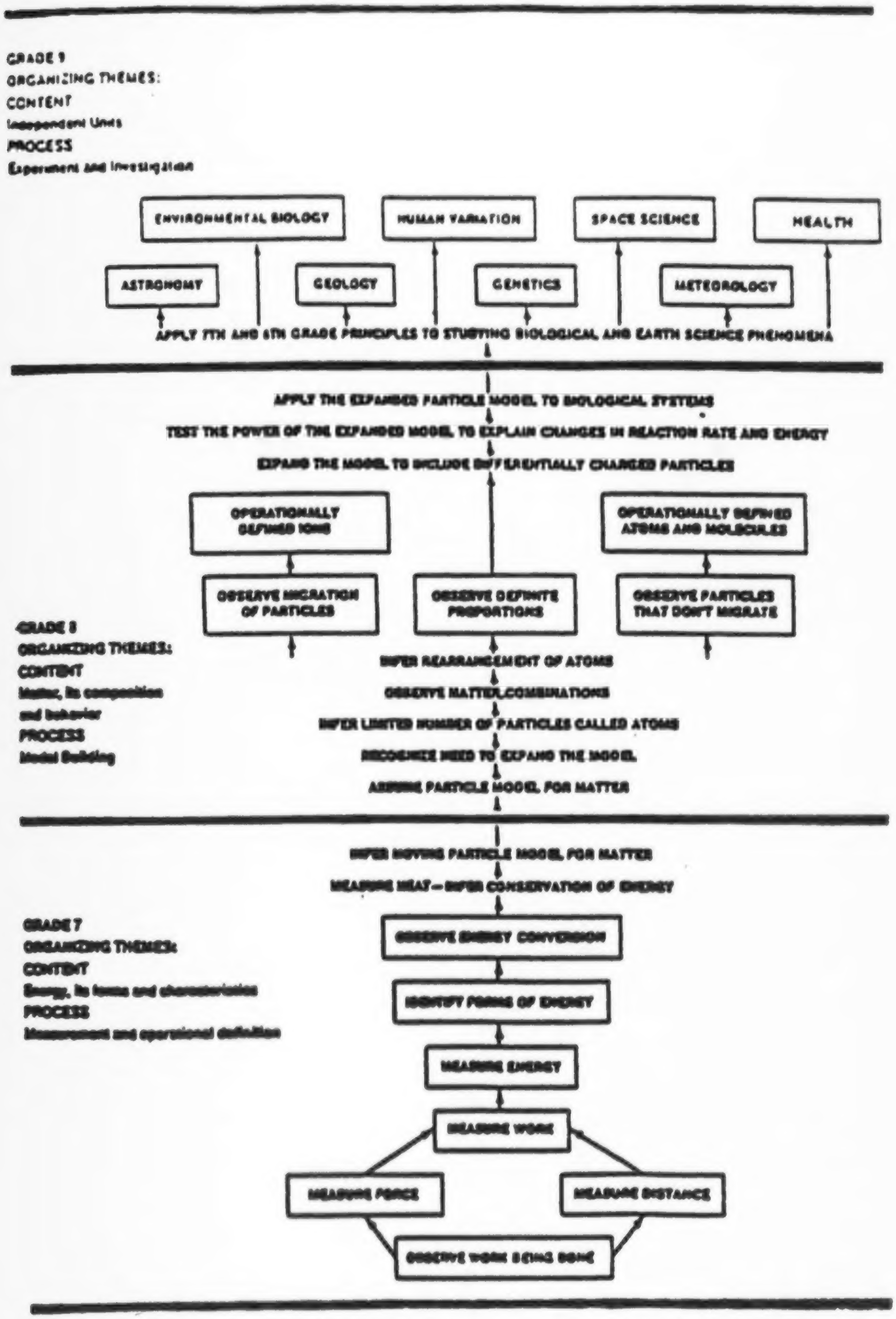
Perhaps the best way to describe curriculum models is to cite a few examples.

Figure 5 shows a model of part of the ISCS (Intermediate Science Curriculum Study) self-paced science program. A quick viewing of this model shows the content and process involved in the grade 7, 8, and 9 programs.

Figure 6 shows a three dimensional grid suggesting major areas of objectives in environmental education.

Figure 7 shows a developmental needs model for primary level children. This model was generated by a teacher group and used as the basis for a K-3 language arts program.

Diagram of ISCS content flow · Probing the Natural World Grades 7 through 9


GRADE 9
ORGANIZING THEMES:
CONTENT
Independent Units
PROCESS
Experiment and Investigation
ENVIRONMENTAL BIOLOGY
HUMAN VARIATION
SPACE SCIENCE
HEALTH
ASTRONOMY
GEOLOGY
GENETICS
METEOROLOGY
APPLY 7TH AND 8TH GRADE PRINCIPLES TO STUDYING BIOLOGICAL AND EARTH SCIENCE PHENOMENA
APPLY THE EXPANDED PARTICLE MODEL TO BIOLOGICAL SYSTEMS
TEST THE POWER OF THE EXPANDED MODEL TO EXPLAIN CHANGES IN REACTION RATE AND ENERGY
EXPAND THE MODEL TO INCLUDE DIFFERENTIALLY CHARGED PARTICLES
OPERATIONALLY DEFINED IONS
OPERATIONALLY DEFINED ATOMS AND MOLECULES
OBSERVE MIGRATION OF PARTICLES
OBSERVE DEFINITE PROPORTIONS
OBSERVE PARTICLES THAT DON'T MIGRATE
GRADE 8
ORGANIZING THEMES:
CONTENT
Matter, its composition and behavior
PROCESS
Model Building
INFER REARRANGEMENT OF ATOMS
OBSERVE MATTER COMBINATIONS
INFER LIMITED NUMBER OF PARTICLES CALLED ATOMS
RECOGNIZE NEED TO EXPAND THE MODEL
ASSUME PARTICLE MODEL FOR MATTER
INFER MOVING PARTICLE MODEL FOR MATTER
MEASURE HEAT—INFER CONSERVATION OF ENERGY
GRADE 7
ORGANIZING THEMES:
CONTENT
Energy, its forms and characteristics
PROCESS
Measurement and operational definition
OBSERVE ENERGY CONVERSION
IDENTIFY FORMS OF ENERGY
MEASURE ENERGY
MEASURE WORK
MEASURE FORCE
MEASURE DISTANCE
OBSERVE WORK BEING DONE

• CLC, 1973 K-12 Science Catalogue Educational Services Limited, Agincourt, Ontario. p. 11.

Figure 5: ISCS Content Flow

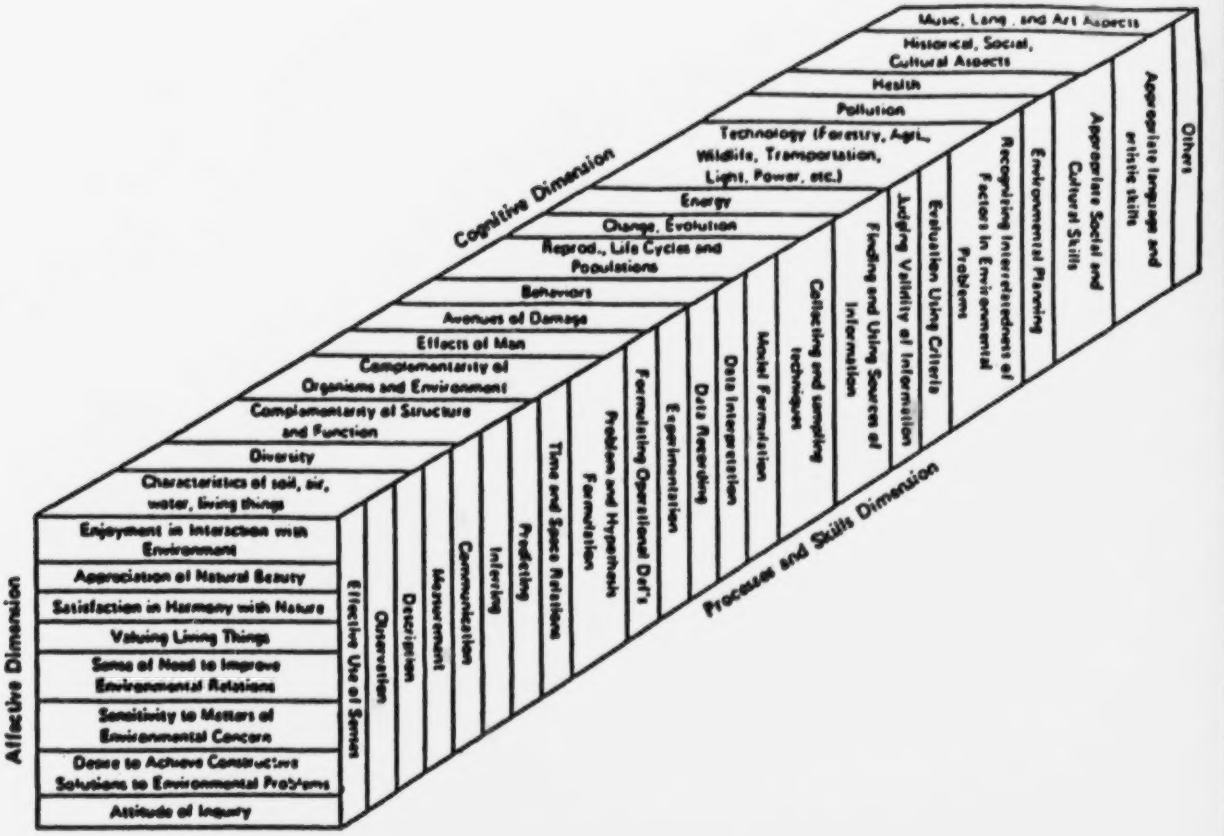

Cognitive Dimension
Music, Lang., and Art Aspects
Historical, Social, Cultural Aspects
Health
Pollution
Technology (Forestry, Agri., Wildlife, Transportation, Light, Power, etc.)
Energy
Change, Evolution
Reprod., Life Cycles and Populations
Behaviors
Avenues of Damage
Effects of Man
Complementarity of Organisms and Environment
Complementarity of Structure and Function
Diversity
Characteristics of soil, air, water, living things
Affective Dimension
Enjoyment in Interaction with Environment
Appreciation of Natural Beauty
Satisfaction in Harmony with Nature
Valuing Living Things
Sense of Need to Improve Environmental Relations
Sensitivity to Matters of Environmental Concern
Desire to Achieve Constructive Solutions to Environmental Problems
Attitude of Inquiry
Processes and Skills Dimension
Effective Use of Senses
Observation
Description
Measurement
Communication
Inferring
Predicting
Time and Space Relations
Problem and Hypothesis Formulation
Formulating Operational Def's
Experimentation
Data Recording
Data Interpretation
Model Formulation
Collecting and sampling techniques
Finding and Using Sources of Information
Judging Validity of Information
Evaluation Using Criteria
Recognizing Interrelatedness of Factors in Environmental Problems
Environmental Planning
Appropriate Social and Cultural Skills
Appropriate language and artistic skills
Others

Figure 6: Major Areas of Objectives in Environmental Education

Primary Level Developmental Needs Model

Characteristics of Whole Child	NEEDS	MEANS
Physical	1. Coordination 2. Adequate sensory perceptions 3. General good health	1. Manipulative materials 2. Listening activities, auditory & visual discrimination, sensory experiences, enunciation skills 3. Cleanliness, neatness, basic health rules
Emotional	1. Self-confidence 2. Honest expression of one's emotions & feelings (within socially acceptable norms) 3. Tolerance and understanding of other's emotions and feelings	1. Success oriented experiences (praise as positive reinforcement) 2. Cultural activities (ex. art, drama, music, P.E.) 3. Role playing (examples of tolerance in teacher and child model).
Social	1. Respect (a) people (b) environment 2. Socially accepted behavioral code 3. Self-responsibility 4. Inner discipline 5. Understanding of differing family units 6. Sense of fair play (justice)	1. (a) sharing experiences cooperative experiences individual experiences relaxing experiences (b) instill respect for property (ultimate responsibility of man for his environment) 2. Discussions of behavioral expectations, establishment and maintenance of school and classroom rules. Read for such (survival) (manner and courtesies). 3. Initiation and completion of tasks (assigned class and classroom duties - housekeeping, etc.). 4. Organization and order 5. Investigate structure of families 6. Know rules and consequences of breaking the rules
Intellectual	1. Stimulation 2. Develop skills 3. Discipline tastes (intelligent choice) 4. Conformity within a system (preserving the right balance between freedom and authority).	1. Provide enriching experiences through models, field trips, audio visual aids. 2. Vocabulary, reading,word recognition, printing, writing, spelling, communication (art, music, math) 3. Provide ample opportunities for intelligent choosing & opportunities to assume responsibility for his decision. 4. Teacher must provide guidance as well as give the child some freedom of choice. (freedom of choice within guidelines).

Figure 7: Primary Level Developmental Needs Model

The models illustrated on the preceding pages may be used to consider important criteria in model building. Using the criteria listed below, study and evaluate each model in Figures 4-6.

1) Does the model illustrate a philosophy?
2) Does the model give a quick picture of the curriculum?
3) Is the model easily reproducible?
4) Are one or more dimensions of the model open-ended?
5) Can the model provide a basis for comparing similar curricula?

Task #8: A Curriculum Model[7, 8]

Purpose: To provide a "big picture" overview of the project.

Review your draft philosophy and need prioritization. Using this review and consideration of the above five items, generate a model for your curriculum.

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[7] Johnson, M. (1967) "Definitions and Models in Curriculum Theory." Educational Theory No.17, pp.127-140.

[8] Saylor, J.G. and W.M. Alexander (1974). Planning Curriculum for Schools. New York: Holt, Rinehart and Winston, pp. 189-244.

Step 8: A Curriculum Framework

The Discrepancy Evaluation Model[9] (DEM) has proven very effective in organizing a curriculum framework. In DEM procedures, information on program components is organized to constitute an operational map. The basic design includes: what is going to happen (activities--process), what should result if the activities are carried out (objectives--outcomes), and what is needed to carry out the activities (resources--inputs). We expanded this basic design to include evaluation questions and sources of data.

In discrepancy evaluation, performance is compared to a standard. The program design serves as a formal representation of that standard and is stated in a form which makes the standard readily subject to evaluation (Yavorsky, 1976, pp. 7-10).

A program design should:

1. facilitate clarification of program goals
2. facilitate the total planning process
3. form a basis of analyzing costs in time and money
4. facilitate assessment of the program plan before implementation
5. provide an implementation guide
6. provide a sense of the whole.

Design may be thought of as a system utilizing inputs (teachers, students, desks, paper, etc.) in processes (classes, practica, testing, etc.) to produce certain outputs (knowledge, skills, attitudes, etc.). Inputs (I), processes (P), and outputs (O) can be conceptualized at different interacting levels.

Appendix I contains segments of a DEM for an elementary teacher science methods course. Refer to this information for a sample of a completed DEM. Note that the model includes a flow chart for all major components of the course, program goals for each major component, topical listings, student objectives, IPO's, evaluation questions and sources of data. Note that the evaluation component is built into the model.

Task #9: A Curriculum Framework

Purpose: To organize a logical framework of topics, objectives, and evaluation concerns that will serve as the basis of a course offering.

Using the concept map generated earlier, the philosophy, the prioritized needs, and intuitive talents, develop a DEM for your project. This should include a component flow chart, program goals for each component, topics, objectives, IPO's, evaluation questions, and a listing of potential sources of data.

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[9] Yavorsky, D.K. (1976, November). Discrepancy Evaluation, a Practioners' Guide. Charlottesville, Va.: University of Virginia Evaluation Research Center.

Step 9: Advisory Committee Review

The process of developing a Curriculum Model and Curriculum Framework has probably taken a considerable amount of time. At this point, it would be well to have the Advisory Committee review progress to date and provide input for revisions.

Step 10: A Curriculum Draft

The magnitude of this step in the curriculum development process will depend on the format selected for the materials. If the format is to consist of only a curriculum framework in the form of IPO's, then the curriculum draft is completed. However, if the final product is to consist of a teacher's manual and/or student textbooks, there is much yet to be accomplished.

The process of writing textbooks is beyond the scope of this users manual. If you are planning to publish a textbook, submit your philosophy statement and curriculum framework, along with a sample chapter to a prospective publisher. If accepted, the publisher will provide detailed prescriptions for the final product.

Step 11: Advisory Committee Review

The curriculum draft should be reviewed before field testing. Depending on the volume of material, this may be a lengthy process. Feedback from the Advisory Committee should be seriously considered by the project director and writing team. Where appropriate, revisions should be made.

A practical approach to this step is to request written comments on the curriculum draft. These written comments can then be reviewed by the writing team. If appropriate, an Advisory Committee meeting can be arranged.

Step 12: Field or Pilot Testing

At the university level, the field test is probably the transition from a former program to the new curriculum and the project director is probably the instructor. The bias built into such a field test is not necessarily undesirable. The curriculum needs to work for the people using it.

The DEM sample in Appendix 1 gives some examples of discrepancies that occurred during the implementation of a science methods course. Review this material.

As your course is taught, use the evaluation questions in your DEM as guides to look for discrepancies.

Step 13: Curriculum Revision and Documentation

Initial experiences with a new program will always lead to revisions. The evaluation components of the DEM should form a sound basis for revisions. Ultimately, all curriculum components should be documented as ideal or acceptable. At this point you have a final product.

Appendix I

A SAMPLE DEM

Introduction

This report contains documentation of the status of EL. ED. 401, Science Methods, and related total program components of SODIA-Science. Figure A1 illustrates all course components. Prerequisites to the course include: Biology 101, Chemistry 101, Geology 101, and Physics 120. Status of the prerequisite courses will be discussed under topics 2.0 and 3.0 of the course evaluation plan. Broad program implications are discussed at the conclusion of this paper.

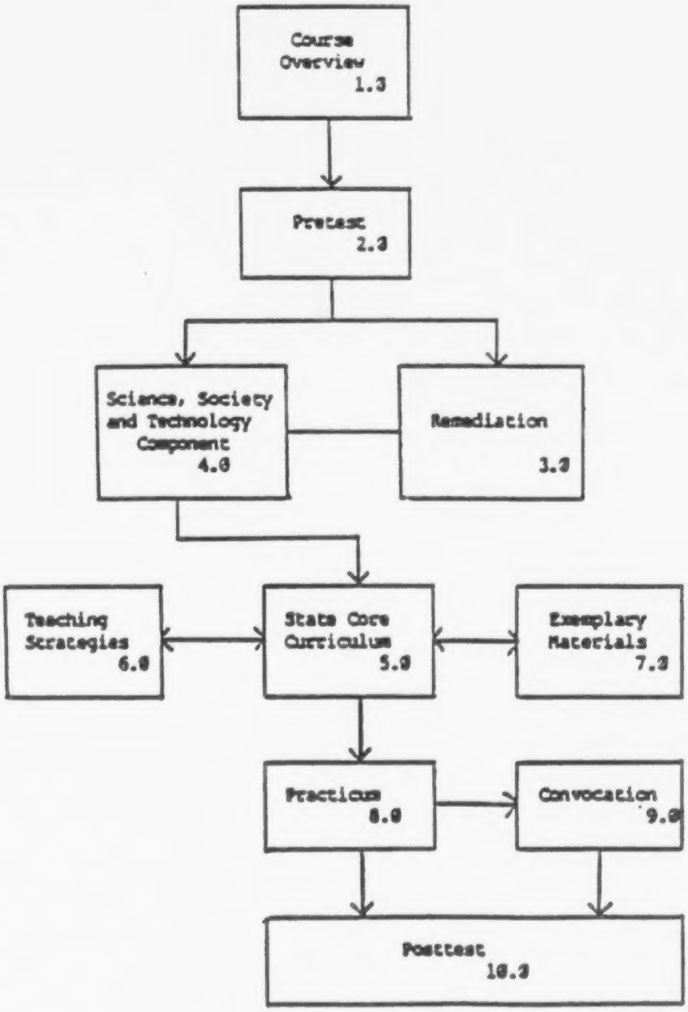
Course Overview 1.0
Pretest 2.0
Science, Society and Technology Component 4.0
Remediation 3.0
Teaching Strategies 6.0
State Core Curriculum 5.0
Exemplary Materials 7.0
Practicum 8.0
Convocation 9.0
Posttest 10.0

Figure A1: El Ed 401, Science Methods (5 credits)
Component Flow Chart

Curriculum goals and objectives are presented in the section that follows, as stated in the original conceptual framework. The original conceptual framework served as an organizational tool for curriculum development. Each component is then followed by IPO's that have been expanded to include evaluation questions, sources of data, and a discussion of status of the component. The goals and objectives are then restated in revised final form as appropriate.

Component 1.0

Program Goal 1.0 To provide an overview and outline of course requirements and procedures.

Topic 1.1 Course Outline

Objectives: The student should:

1.11 be familiar with the components of the course.

INPUTS	PROCESS	OUTPUTS
Students	The instructor provides a verbal and written description of the course.	Students will have an understanding of course goals, objectives, and procedures.
Printed course outline		
Classroom to seat 50	Time: 15 minutes	

Evaluation Questions	Sources of Data
How well do students understand course requirements?	Course Evaluation forms Instructor-student discussions

Discussion and Recommendations

The procedures for this component were evaluated for three terms. The initial estimate of 15 minutes for this component was insufficient. Time has been increased to 30 minutes. The written description has not changed, but discussion has been expanded. Winter term student rating for this was 4.56 indicating a very positive student response to the procedure. The increase in time was a result of frequent student questions about grading and course components. On the basis of this feedback, the only revision in this component is to increase the time to 30 minutes.

Topic 1.2 Requirements and Grading

Objectives: The Student should:

1.21 be aware of course requirements and options for achieving them.

1.22 understand grading procedures for all components of the course.

Evaluation Questions	Sources of Data
How well do students understand grading procedures and course requirements? Are students aware of options for achieving course requirements?	Course evaluation forms Instructor discussion and observation of student behavior Aid discussions with students

Discussion and Recommendations

Students rated the grading component very high (4.81) on the winter term course evaluations. The course options were related to Topic 1.1. Expansion of time devoted to discussion of the course flow chart and course goals and objectives have given students a good understanding of what will happen in the course. Further assurance that this conclusion is correct was supplied by an aid whose function was to help students that did not understand what was happening. The aid was not consulted at all during spring term on matters related to course requirements or grading. On the basis of the above data no changes are recommended for component 1.2.

Topic 1.3 Record Keeping

Objectives: The student should:

1.31 be able to utilize computer-managed record keeping procedures for the purpose of demonstrating progression within the course.

INPUTS	PROCESS	OUTPUTS
Students in groups of 12 Computer terminal One floppy disk per student	The instructor will explain and demonstrate how the computer will be used for testing. Each student will initiate their own computer file for the course.	Students will demonstrate ability to use the computer to manage record keeping for their progress in the course.

Evaluation Questions	Sources of Data
How functional is the technology? How well do students utilize the technology?	Instructor feedback Course evaluation forms Student questionnaires

Discussion and Recommendations

The unstated course objective for this component was to introduce students to computer-managed record keeping. The intent was to utilize Apple IIe computers and a Corvus hard disk system in the Edith Bowen Laboratory School. The initial challenge was facilitating student entry into the system. As designed, the system allowed three levels of entry: the principal had entry to all processes, an instructor had entry at specified course levels to record and observe data, and students had entry at the course level to observe personal data. There was much concern among laboratory school faculty in allowing methods course students to enter some of their own data. Therefore, the initial approach was to allow methods course students to only observe their personal course progress. Fall term usage was minimal. Only five students in a group of 76 checked their scores. It was concluded that the low usage, management problems, and time to record the data were sufficient reasons to totally drop this course component.

Introduction to the technology was incorporated into Component 5.1.

Final form of Component 1.0

Program Goal 1.0 To provide an overview and outline of course requirements and procedures.

Topic 1.1 Course Outline

Objectives: The student should be familiar with course components.

INPUTS	PROCESS	OUTPUTS
Students	The instructor provides a verbal and written description of the course.	Students will have an understanding of course goals, objectives, and procedures.
Printed course outline		
Classroom to seat 50	Time: 30 minutes	

Topic 1.2 Requirements and Grading

Objectives: The student should be aware of course requirements and options for achieving them.
The student should understand grading procedures.

INPUTS	PROCESS	OUTPUTS
Students	The instructor provides a verbal and written explanation of course requirements and grading procedures.	Students will be aware of course requirements and options for achieving them.
Printed course requirements		
Instructor		Students will understand grading procedures for all components of the course.

Time: 15 minutes

Component 2.0

Program Goal 2.0 To provide means of determining student level of scientific literacy.

Topic 2.1 Content Area Assessment

Objectives: The student must:

2.11 achieve a score of at least 80% in each of four (biology, geology, earth science, physics) content area assessments.

INPUTS	PROCESS	OUTPUTS
Students Personal record disk Content area assessment disk	Students will utilize a computer-mediated assessment procedure to self-preassess content area competencies in biology, geology, chemistry, and physics. Time: TBA	Students performing at below 80% level will be identified.

Evaluation Questions	Sources of Data
How well does the testing procedure operate? Has the pretest been validated? What is the reliability of the pretest? Are the prerequisite courses properly preparing the students?	Instructor feedback Course evaluations Validation process Test data Advisory Committee

Discussion and Recommendations

The original intent was that pretesting would be a computer-mediated process, with student testing done out of class and remediation specified on a computer printout. This has not been achieved, due largely to problems with graphics on the available Apple IIe computers. At the writing of this report (April, 1987) the technology problems are still being worked on.

The process followed for the three 1986-87 terms has proven very satisfactory, i.e., The pretest is administered as a group paper-and-pencil test during one of the early class sessions. Testing requires one hour and correcting and posting subscores requires an additional two hours of faculty time. This process is as time efficient as the proposed computer-mediated procedure. Student time commitment would have be greater in the original approach and lab assistance of a media specialist amount of time would have been equal to present instructor time commitment. Course evaluations have rated the present procedure highly.

The conclusion at this point is that present process is most acceptable, but that the computer-mediated approach bears further investigation. Douglas Allred has designated the validation of the computer-mediated testing procedure as his masters thesis investigation. He will conclude this study fall term 1987, at which time the process for 2.0 will be re-evaluated.

The pretest was modeled after the British Columbia Science Assessment (1982). Validity considerations are covered in the 1982 British Columbia report. Test items were also compared with the standards and objectives stated in the Utah Core Curriculum (1987). All test items had comparable core components. Therefore, it was inferred that the pretest covered topics appropriate for Utah elementary teachers.

The detailed discussion of test results is omitted in this appendix. For the purpose of illustration of a DEM, only the discussion of components 5.0 and 6.0 are included in the remainder of this appendix.

Component 5.0

Program Goal 5.0 To provide background on the origin and requirements of the Utah Elementary Science Core.

Topic 5.1 Elementary Science Core Overview

Objectives: The student should:

5.11 be familiar with the State Core numbering system in order to use it as an aid in a computer-managed curriculum.

5.12 be familiar with the hierarchical arrangement of standards and objectives as stated in the Utah State Science Core.

5.13 examine across-the-curriculum relationships as presented in the Utah Elementary Science Resource Guide.

5.14 identify and explain how all aspects of the Utah Elementary Science Resource Guide relate to the State Elementary Science Core.

INPUTS	PROCESS	OUTPUTS
All students Instructor Classroom State Science Core Utah Elementary Science Resource Guide disks Apple IIe Computers/ printers	In a lecture/discussion situation the instructor will introduce the students to the Utah Elementary Science Core. The Apple IIe computer will be used to introduce the Utah Elementary Science Resource Guide. The instructor will explain how the various aspects of the guide relate to the total elementary curriculum.	Students will be aware of the numbering system, hierarchical arrangement of standards and objectives, and general content of the Utah Elementary Science Core. Students will understand how the Utah Elementary Science Resource Guide is tied to the Core curriculum.

Evaluation Questions

Are students able to use the technology?

Does the process adequately introduce the Utah Core Curriculum and the Elementary Science Resource Guide?

Do students use the resources on their own?

How well does the process relate to the Edith Bowen Lab School Project TINMAN objectives?

Sources of Data

Course evaluations

Test data

Student interviews

Lab school principal interviews

Discussion and Recommendations

This component was an innovative success. Student response has been very positive, as evidenced by course evaluations, and their performance on related exam items has been excellent.

The component is now team taught by the Edith Bowen Lab School principal and the course instructor. The inclusion of the principal was made to provide an introduction to Project TINMAN, a computer-mediated curriculum management system utilized in the lab school in which methods course students do their practicum. The inclusion of the total management system expanded the original intent of using the computer as a resource for science curriculum materials to a more relevant total picture.

The use of computer-mediated videodisc was also added to the presentation.

Over half the students reported using the above described resource during their practicum. None reported negative feelings about the process.

Final form of Component 5.0

Program Goal 5.0 To provide background on the origin and requirements of the Utah Elementary Science Core.

Topic 5.1 Elementary Science Core Overview

Objective: The student will utilize the Utah Core Curriculum and the Elementary Science Resource Guide as examples of computer-managed curriculum.

INPUTS	PROCESS	OUTPUTS
Students Instructor Lab school principal State Science Core Elementary Science Resource Computer facilities	The Utah Elementary Science Core will be introduced in a lecture/discussion session. This will then be tied to a computer-mediated curriculum resource including the Elementary Science Resource Guide. Time: 1 1/2 hours	Students will understand the relationships between the State Elementary Science Core and the Elementary Science Resource Guide. Students will utilize a computer-managed curriculum process to obtain science teaching resources.

Component 6.0

Program Goal 6.0 To apply teaching principles, skills and methods to teaching elementary science.

Topic 6.1 Scientific Literacy

Objectives: The student should:

6.11 be able to define scientific literacy.

6.12 Identify and/or devise lesson plans that promote improvement in scientific literacy.

6.13 identify and/or devise means of assessing student levels of scientific literacy.

INPUTS	PROCESS	OUTPUTS
All students Instructor	A reading will be used to introduce the concept of scientific literacy.	Students will be able to define scientific literacy.
Utah Elementary Science Resource Guide Discs	The Utah Elementary Science Resource Guide will be used to illustrate various plans and procedures for increasing and assessing levels of scientific literacy.	Students will be able to recognize examples of lessons that develop comprehension, application, and attitude components of scientific literacy.
	Time: 1 hour	Students will be able to identify and devise assessment items that measure various aspects of scientific literacy.

Evaluation Questions

How well do students achieve objectives?

Does the process, as defined, match what happens in the classroom?

Sources of Data

Course evaluations

Test data

Interviews

Discussion and Recommendations

The process followed for this component evolved greatly during the 1986-87 school year. The changes did not influence student responses on course evaluations or test results. The changes were made on the basis of instructor comfort. The original assigned reading was changed to a lecture/discussion and the test item development was changed to a specific written assignment.

The lesson plan part of this component was transferred to the practicum and responsibility for evaluation of that experience was assigned to lab school teachers that work with practicum students.

Topic 6.2 Cognitive Processes

Objectives: The student should:

6.21 know and apply principles of cognitive psychology to teaching elementary science.

INPUTS	PROCESS	OUTPUTS
All students Textbook examples Laboratory facilities Instructor	Readings will provide a review of Piagetian principles of cognitive psychology. These principles will be related to elementary science classroom experiences that students may read about and actually carry out in the laboratory if they so desire. Time: TBA	Students will understand potential implications of cognitive psychology for teaching science. Students will relate Piagetian stages of development to specific types of science activities.

Evaluation Questions	Sources of Data
How well do students achieve objectives? Does the process, as stated, reflect what happens in the classroom?	Course evaluations Test data Student interviews Discussion with other faculty

Discussion and Recommendations

The objectives for this component were never met. Students did not have these competencies at the end of either fall or winter terms. Furthermore, the instructor anticipated these results and course evaluations for this component were low during both terms. The objectives and process were discussed at some length with other faculty who were more competent in learning theory. There was a general consensus that the objectives were sound, but that students did not come to the experience with sufficient background to transfer their learning to such a complex task. It was pointed out that the instructor was attempting to put a full course into less than three hours. It was decided that the objectives were unrealistic, given the background of the students. The Advisory Committee concurred with this decision and suggested that the deficiency in the total program be examined.

Spring term the instructor replaced the cognitive processes component with a historical perspectives component. This was well received by the students and added an important dimension to the course. Test data indicated that students assimilated this knowledge well.

Topic 6.3 Multidisciplinary Aspects

Objectives: The student should:

6.31 be able to relate science objectives to goals and objectives in other subject matter areas at the same grade level.

6.32 be able to identify and/or plan science lessons that integrate other subject matter areas with science.

INPUTS	PROCESS	OUTPUTS
All students Classroom Instructor Elementary Science Resource Guide	The instructor will model a number of examples tying science to other parts of the elementary curriculum. Time: 1 hour	Students should relate science objectives and goals to goals and objectives in other subject matter at the same grade level. Students should be able to apply principles learned in this component to practicum and/or convocation experiences.

Evaluation Questions	Sources of Data
How well do students achieve objectives? Are there any problems in the delivery system? Does the process as stated match what happens in the classroom?	Course evaluations Test data

Discussion and Recommendations

Student performance on test items and course evaluations confirmed that this component is achieving the stated objectives. The total time spent on this concept was more than originally stated and both input listings and process descriptions needed expansion to match what actually happened in the classroom.

Topic 6.4 Laboratory Techniques and Equipment

Objectives: The student should:

6.41 be familiar with laboratory equipment commonly used in elementary science programs.

6.42 be aware of hazards and safety precautions associated with elementary science laboratory work.

INPUTS	PROCESS	OUTPUTS
Students Instructor Equipment lists Station studies/ equipment Lab safety manuals	Students will follow self-instructional procedures to familiarize themselves with common elementary science equipment and procedures. These learning experiences will be set up in stations with instructional strategies, equipment, and lab safety references.	Students should be familiar with laboratory equipment commonly used in elementary science programs. Students should be aware of hazards and safety precautions associated with elementary science laboratory work.

Evaluation Questions	Sources of Data
How well do students achieve objectives? Are there deficiencies in either inputs or processes?	Test data Course written assignments Course evaluations Interviews Advisory Committee NSTA-Elementary Committee

Discussion and Recommendations

The hazards and safety precautions section of this component was a success. Students used a study guide and a lab safety manual to self-instruct with respect to the objective. The required written assignment and test results confirmed that students understood the basics of lab safety. No changes occurred in this component over the three 1986-87 terms.

Familiarity with laboratory equipment and materials commonly used in elementary classrooms was not achieved. It was assumed that this background would have been achieved in the four foundation science courses and that a brief review would suffice at this point. During fall term, an informal assessment of student knowledge was conducted. The results were amazingly poor. During winter term, more detailed analysis was carried out. Over half of the students answered 21 of the 30 items incorrectly. Only three of the items were answered correctly by over 80% of the students. The conclusion was that the entire area of equipment and materials knowledge needed review.

These data were discussed in some detail at the Winter Advisory Committee Meeting. It was generally agreed that the instrument had weaknesses, but in general it pointed out that the four foundation science courses were not providing appropriate "hands-on" laboratory experiences. Greatest problems seemed to be in the chemistry-related items. The advisory committee suggested that a validated instrument be designed to better measure competencies. This suggestion was followed by a funding proposal submitted to the faculty of education research committee and was funded for $1950. Validation and item efficiency were determined in 1987.

General consensus among science faculty on the Advisory Committee was that if the magnitude of the problem is as great as preliminary testing indicated, then major revisions need to be made in the lab components of the four prerequisite science courses. It was further recommended that the Process part of Topic 6.4 be modified to indicate that remediation be required where students do not achieve 80% in the Equipment Inventory. This recommendation will be acted upon until testing is carried out with a validated instrument.

Final form of Component 6.0

Program Goal 6.0 To apply teaching principles, skills and methods to teaching elementary science.

Topic 6.1 Scientific Literacy

Objective: The student will define scientific literacy, apply the concept to classroom situations, and identify or devise means of assessing student levels of scientific literacy.

INPUTS	PROCESS	OUTPUTS
Students Instructor	The concept of scientific literacy will be introduced in a lecture/discussion session.	Students will define scientific literacy.
Various curriculum materials Test item development handout	Various curriculum materials and handouts will be used to assist in developing assessment items.	Students will recognize examples of lessons that develop comprehensive application and attitude components of scientific literacy.
	Time: 1 1/2 hours	Students will identify and devise assessment items that measure the components of scientific literacy.

Topic 6.2 Historical Perspective

Objective: The student will demonstrate a basic understanding of the development and characteristics of elementary science curricula over time.

INPUTS	PROCESS	OUTPUTS
Students Instructor Samples of: Heath Science, Silver Burdette, PLT, SCIS, ESS, ESSP.	The instructor will provide historical background on the evolution of elementary science curricula. Sample materials illustrating various approaches to teaching elementary science will be made available. Time: 1 1/2 hours	The student will identify and describe examples of four generations of elementary science curricula The student will identify strengths & weaknesses of various elementary science curricula.

Topic 6.3 Multidisciplinary

Objectives: The student will investigate potential for integrating elementary science with the total elementary curriculum.

INPUTS	PROCESS	OUTPUTS
Students Classroom Instructor	The instructor will model a number of examples tying science to other parts of the elementary curriculum.	Students will relate science objectives to objectives in other subject areas.
Elementary Science Resource Guide ESSP	Resources will be shared that exemplify integration of science with other subject areas.	Students will apply principles learned in this component to practicum and/or convocation experiences.
PLT, PW	Time 1 1/2 hours	

Topic 6.4 Laboratory Techniques and Equipment

Objective: The student will demonstrate familiarity with laboratory equipment and supplies commonly used in the elementary science programs. The student should be aware of hazards and safety precautions associated with elementary science laboratory work.

INPUTS	PROCESS	OUTPUTS
Students Instructor Lab Safety manual School Science Safety	Students will follow self-instructional procedures to familiarize themselves with common elementary science equipment, supplies, and safety procedures.	Student will identify, describe, and appropriately use common elementary science equipment and supplies.
Station Studies/ equipment		Students should be aware of hazards and safety precautions associated with elementary science laboratory work.